

The Blast Furnace and Steel Plant

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The Blast Furnace *and* Steel Plant

Vol. XVI

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No. 4

A Maker of Steel

A LONG the east shore of the Hudson river, below the city of Troy, one may still see the crumbling foundations of the first Bessemer plant in America. This plant was built in 1865 under the supervision of Alexander Lyman Holley, who had secured for the firm of Corning Griswold & Company the American patent rights to the process.

Holley's life as a steelmaker was unique in that, until he was 31 years of age, he had taken no great interest in the manufacture of iron or steel. In fact, his only engineering experience had been in the design of locomotives and steam engines. But as an editor and contributor to scientific magazines, he made many investigations of a technical nature, and in this manner obtained a general knowledge of machinery which was of inestimable value in developing the Bessemer process.

Bessemer steel did not assume commercial importance in America until 1867, the year in which the plant at Troy emerged from the experimental stage, and to Holley must go the credit for those improvements that assured success.

Just as the name of John Fritz is linked with the three-high mill, so is the name of Alexander Holley associated with the Bessemer process in America. Holley made the Bessemer process a commercial success, but to do so he had to use to the limit his courage, his inventive faculties and the results of his experience. He had to find refractories that would stand the heat and erosion; he had to assemble blowing equipment that would not fail at a critical moment; and, finally, he had to discover what analysis of pig metal was best suited to the process and then procure a supply of this metal.

Alexander Holley's work is quite forgotten, but the process he fostered still survives although it, too, has declined with passing years.

Deoxidation of Iron with Manganese*

Theoretical and Experimental Investigation of Compounds of Manganese in Iron and the Process of Deoxidation by Addition of Manganese—Effects on Basic Slags

By J. M. GAINES, Jr.†

DURING the last ten years, increased attention has been paid to the occurrence of oxygen in steel, on account, primarily, of its effect on the quality of the material. Oxygen does not exist in the elementary condition, but as oxide, mainly as FeO. In killed steel, of course, a considerable quantity of oxygen has been found in the form of silica and alumina; whether these substances are dissolved or suspended in the liquid bath cannot now be determined. However, it is theoretically possible for dissolved silica and other dissolved oxides to combine, forming silicates. It is obvious that the same quantity of total oxygen will have a different effect on the quality of the steel, depending upon the particular form in which it is present.

Analogous to this condition is that found in the case of the sulphides. An addition of manganese withdraws some of the sulphur from combination as iron sulphide, although a change in the total sulphur content of the metal does not take place. Upon deoxidation a part of the oxygen which is present as ferrous oxide is converted to other oxides, such as manganous oxide, or silica, which are nearly or entirely insoluble in iron. The deoxidation products are then eliminated from the bath more or less rapidly depending on their densities and the size of the particles. After deoxidation a certain quantity of oxygen remains—even when time is allowed for elimination of the reaction products—and complete removal of oxygen can only be obtained by special methods—such as melting under vacuum.

Study of the deoxidation with manganese affords an excellent example of the application of physical chemistry and of the correlation of theory and practice.

Le Chatelier¹ has calculated from the heats of formation of MnO and FeO and the Carnot-Clapeyron equation, the partial pressure of oxygen at equilibrium for the reaction



and finds the equilibrium constant at 1600 deg. C.

$$K = \frac{\text{Mn}}{\text{FeO}} = 0.11,$$

where the concentrations are weight per cent in the metal.

Styri² and McCance³ have also calculated this constant using the Nernst Heat theorem, and find 0.37 and 0.091 respectively. Unfortunately the data upon which these values are based are not entirely reliable, as may be evidenced by the disparity among the three figures given. Furthermore, the assumption must be

*Based on original paper by P. Oberhoffer and R. Schenck, *Stahl und Eisen*, September 15, 1927, p. 1526, with comments by the translator.

†Assistant physical chemist, Pittsburgh Experiment Station, U. S. Bureau of Mines.

¹Rev. Met. 9, 1912, p. 513.

²J. Iron & Steel Inst., 108, 1923, p. 189.

³Trans. Faraday Soc., 21, 1925, p. 188.

made that MnO—product of the reaction—is dissolved in the steel, if at all—as the pure compound; what data there are point to the existence of a mixture of FeO and MnO as the dispersed phase, rather than simply MnO.

The true expression of the equilibrium in the metal is

$$K_L = \frac{(\text{MnO})}{(\text{Mn})(\text{FeO})},$$

which states that a given temperature and with a certain amount of manganese in the bath, the ratio of the oxides is established; and that with rising manganese the fraction of MnO in the dispersed phase will increase. And from the fact that with decreasing manganese, the total oxygen in the metal rises, it may be concluded that the higher the proportion of MnO, the less soluble is this mixture of oxides.

Process of Deoxidation

Deoxidation may also be pictured in the following way. Upon addition of manganese, a certain amount of ferrous oxide is converted to manganous oxide, which is precipitated from solution on account of its low solubility. The remaining iron oxide will then distribute itself between metal and the manganous oxide phase—and thus all but a small amount will be eliminated from the bath. There will then be definite relations between the amount of oxides in slag and metal. It is impossible to determine directly the value of this relationship—known as the distribution ratio. Nor may K_L be evaluated directly, owing to the fact that analytical methods are not adequate to the determination of FeO or MnO separately as constituents of the metal bath.

This obstacle can be overcome, however, if a pair of melts be made in which the concentration of manganese is made to vary somewhat. This will yield two sets of data including the percentages of manganese in the metal, manganous oxide in the slag, and total oxygen in the metal. The two equations expressing the relation between these concentrations, the distribution ratio and K_L , may be solved for the last two quantities.⁴

⁴The method of computation referred to is the following. If the distribution ratios be defined, $L_{\text{FeO}} = (\text{FeO}) \div [\text{FeO}]$; $L_{\text{MnO}} = (\text{MnO}) \div [\text{MnO}]$ where () denotes slag concentration and [] metal concentration, the equilibrium may be expressed: $K = [\text{FeO}][\text{Mn}] \div [\text{MnO}]$. Instead of $[\text{FeO}]$ and $[\text{MnO}]$ may be used the concentrations of oxygen contained in the respective oxides, i.e., $[\text{O Fe}]$ and $[\text{O Mn}]$. Then, in a melt containing only Fe, Mn, and O, $[\text{O Fe}] + [\text{O Mn}] = [\text{Total O}] = [\Sigma \text{O}]$, $[\Sigma \text{O}]$ may be determined analytically. Now $K' = [\text{O Fe}][\text{Mn}] \div [\text{O Mn}]$ or $K' \div [\text{Mn}] = ([\Sigma \text{O}] - [\text{O Mn}]) \div [\text{O Mn}] = [\Sigma \text{O}] \div [\text{O Mn}] - 1$ but $[\text{O Mn}] = (\text{MnO}) \div L$. Hence the complete relation is $K' + 1 = [\Sigma \text{O}] \cdot L \div (\text{MnO})$ in which K and L are to be determined. Two melts at the same temperature and at nearly the same concentrations give two simultaneous equations which may be solved for these two quantities.

Experimental Determinations

Two series of melts were made under vacuum to study the equilibrium of the reaction. In the first manganese was added to liquid iron containing iron oxide; in the second manganous oxide was added to iron, so that equilibrium was reached from both sides. The samples thus obtained were analyzed for manganese and total oxygen. Five of the melts of the second series yielded sufficient slag for analysis and on these MnO and FeO was determined. All melts were made at 1600 deg. C.

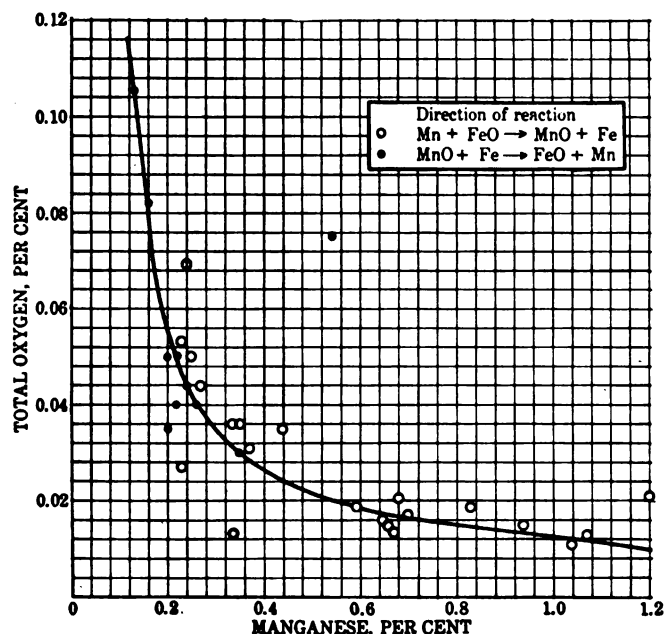


FIG. 1—Equilibrium between manganese and oxygen at 1600 deg. C.

Fig. 1 shows the results of all the determinations. It will be seen that the relation between manganese and oxygen in the metal is a hyperbolic curve. The data are given in Tables I and II.

Results of the five melts from which the slag was analyzed are shown in Fig. 2 and in Table III. The column headed "MnO ÷ FeO, corrected," as well as

TABLE I
Reaction: $\text{FeO} + \text{Mn} \rightarrow \text{Fe} + \text{MnO}$ at 1600 deg. C.

Sample No.	Mn, per cent	Total oxygen, per cent
O 1	0.37	0.031
O 2	0.70	0.017
O 3	0.83	0.019
O 4	0.94	0.015
O 5	0.35	0.036
O 6	0.27	0.044
O 7	0.68	0.021
O 8	1.21	0.051?
O 9	0.65	0.016
O 10	0.23	0.053
O 11	0.67	0.014
O 12	0.34	0.036
O 13	0.59	0.019
O 14	1.07	0.013
O 15	1.20	0.021
O 16	0.24	0.069
O 17	0.66	0.015
O 18	0.36	0.013
O 19	1.04	0.011
O 20	0.42	0.035
O 21	0.250	0.050
O 22	0.23	0.027

TABLE II

Reaction: $\text{Fe} + \text{MnO} \rightarrow \text{Mn} + \text{FeO}$ at 1600 deg. C.

Sample No.	Mn, per cent	Total oxygen, per cent
R 13	0.54	0.075
R 14	0.26	0.040
R 15	0.24	0.044
R 16	0.35	0.030
R 17	0.16	0.082
R 18	0.13	0.115
R 19	0.20	0.050
R 20	0.20	0.035
R 21	0.22	0.050
R 22	0.22	0.040

TABLE III

Manganese and oxygen in the metal and the composition of the deoxidation products.

Sample No.	Total oxygen, per cent	Mn, per cent	$\frac{(\text{MnO})}{(\text{FeO})}$	$A = \frac{(\text{MnO})}{(\text{FeO})[\text{Mn}]}$	$\frac{(\text{MnO})}{(\text{FeO})}$ corrected
R 18	0.115	0.13	0.339	2.58	0.344
R 21	0.050	0.22	0.542	2.43	0.581
R 15	0.044	0.24	0.675	2.78	0.632
R 14	0.040	0.26	0.713	2.70	0.685
R 16	0.030	0.35	0.901	2.54	0.925
Average				2.61	

the solid points on the plot have been obtained by taking the average value of 2.61 for the expression $\frac{(\text{MnO})}{[\text{Mn}](\text{FeO})}$. This value, multiplied by the percentage of manganese in the bath gives the ratio of the two oxides.

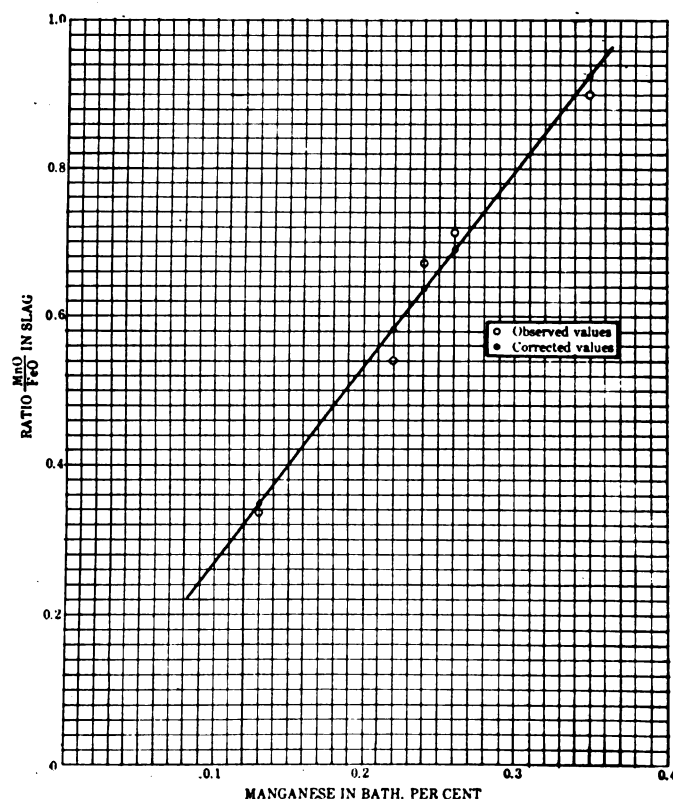


FIG. 2—Relation of per cent manganese in bath to the MnO/FeO in the slag.

On attempting to calculate the equilibrium constant for the reaction by the method outlined above, negative values result, which are, of course, without significance.

There are two possible explanations for this apparent lack of concordance between the theory and the experimental results.

1—The equilibrium constant, K , is not only dependent on the temperature, but is also a function of the iron-oxide content of the metal.

2—The values for the total oxygen content of the metal require a correction, so that the total oxygen content of the metal will not show a rapid increase with decreasing percentage of manganese as indicated by the analytical results.

In regard to the first, the assumption could be made that manganous oxide of itself is insoluble in iron and dissolves only in the iron oxide already in the bath, so that with increasing amounts of iron oxide in solution, increasing amounts of manganous oxide may also be dissolved. In this way K would be made to depend in some manner on the iron oxide concentration.

The second possibility really concerns the accuracy of the analytical method, and will not be taken up here.

In an effort to determine directly the oxides present, samples in the form of drillings were dissolved in a non-aqueous iodine solution; the insoluble residues, or inclusions, thus obtained were analyzed for manganese with the results shown in Table IV. It is unfortunate that the agreement between the values is so poor.

TABLE IV
Manganous oxide content of iron as determined from extraction of inclusions.

Sample No.	Mn, per cent	Total oxygen per cent	[O Mn]	[O Fe]	$K = \frac{[O Fe][Mn]}{[O Mn]}$
O 10	0.23	0.053	0.0047	0.0483	2.36
O 6	0.27	0.044	0.0082	0.0358	1.18
O 2	0.70	0.017	0.0060	0.011	1.29
O 13	0.59	0.019	0.0036	0.0144	2.44
O 9	0.65	0.016	0.0042	0.0118	1.83
Average.....					1.82

Translator's Note—It is of interest to note that the value for the expression

$$\frac{(\text{MnO})}{[\text{Mn}](\text{FeO})}$$

at 1600 deg. C. has already been determined by Herty.⁵ He obtains the figure 2.36 from observations and analysis of steel and slag in basic open-hearth furnaces. The present authors give 2.61 as the average of five determinations. The agreement between these two values is remarkable, particularly when it is remembered that the first was obtained from 25-gram samples and the second from several 100-ton heats.

The writers state that it is impossible to calculate the equilibrium constant due to the occurrence of negative results, and this is undoubtedly the case. However, it is possible by modifying the equations slightly to calculate the distribution ratios of the two oxides between slag and metal. If this is done, the ratio for FeO, expressed as per cent FeO in the slag divided by per cent oxygen as FeO in the metal, is found to range from 375 to 1025 for the samples given in Table III. It is significant that by this method

⁵Herty, C. H., Jr., Chemical Equilibrium of Manganese, Carbon, and Phosphorus in the Basic Open Hearth Process. Trans. Amer. Inst. Min. & Met. Eng., vol. 73, 1926, p. 1107.

negative values for the distribution ratio of MnO are found. It is of further interest that the ratio for FeO in a slag containing essentially FeO and without any MnO is 339.⁶

As the quantity of MnO in the slags in Table III increases, the distribution ratio goes up. In other words, there is less FeO in the metal for a given concentration of this compound in the slag. What this means is that some of the FeO in the slag is rendered inactive by MnO so far as going into solution in the metal is concerned. It is possible that the two oxides may form a more or less unstable compound in which

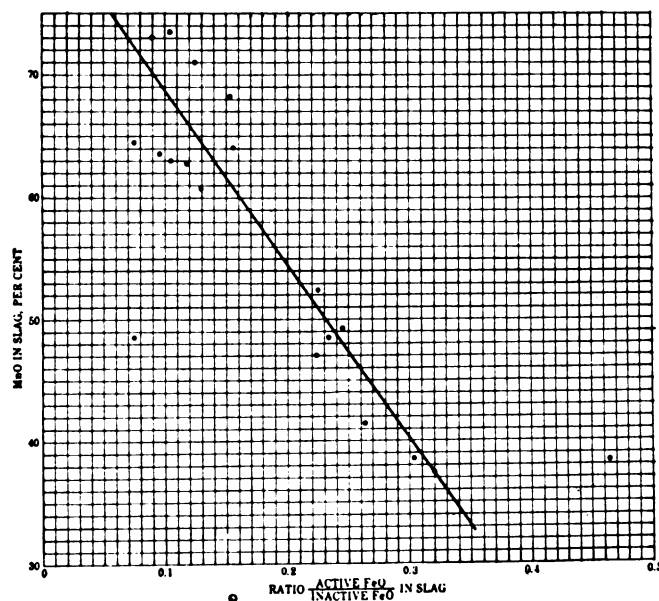


FIG. 3—Effect of MnO on activity of FeO in slag.

the FeO is partially bound so that it is not all free to dissolve in the iron. Such a condition is met, for example, in slags containing iron oxide and silica. This observation is more or less parallel to that of the authors, who state that mixtures of the oxides high in MnO are less soluble in iron than those low in MnO.

A second line of evidence points to the same conclusion regarding the influence of MnO in the slag. If one assumes that the average value of K given in Table IV—namely, 1.82, is sufficiently good for a rough approximation, one may calculate the quantity of oxygen in the metal as FeO and as MnO, providing the percentages of manganese and of total oxygen are known. This was done for the samples given in Table I. Knowing the per cent of oxygen as FeO in the metal, and using the value of 339 for the distribution ratio for FeO between slag and metal, it becomes a simple matter to find the concentration of FeO in the slag necessary to give the observed concentration in the metal, which may be termed the "active" FeO in the slag. This, it appears, is small relative to the rest of the FeO in the slag; the ratio of the active FeO to the "inactive" varies from 0.073 to 0.466. What is most striking is that this ratio is lowest when the concentration of MnO is greatest and increases in a linear relationship as the MnO becomes smaller, as shown in Fig. 3. This also tends to lend support to the hypothesis that MnO reduces the activity of FeO in the slag.

⁶The Physical Chemistry of Steel Making: The Solubility of Iron Oxide in Iron. Bull. 34, Carnegie Inst. of Technology, October, 1927.

(Continued on page 488)

The Cleaning of Blast Furnace Gas*

Purposes for which Gases from Furnace Are Used—Benefits to be Derived from Cooling to 90 Deg. F. and from Fine Cleaning—German Practice and Resulting Economies

By A. J. BOYNTON†
PART I

IN the preparation of this paper the writer has been influenced by the fact that descriptions of various means of cleaning blast furnace gas have been presented in the transactions of this society and elsewhere and that further descriptive treatment of the subject will probably be less interesting than a statement of conclusions with regard to preferable methods which have been reached as a result of experience and observation in this country and also as a result of a somewhat detailed investigation of the subject made by him within the past two months on the continent of Europe and particularly in Germany. Owing to various circumstances, including a cost of fuel which is extremely high in relation to the wages of labor, the German iron and steel industry has accumulated experience in gas washing which is as yet in part lacking in the United States of America. The paper also deals with the economics of the use of blast furnace gas, a statement with regard to which precedes the consideration of the principles and practices employed in its purification.

Uses of Blast Furnace Gas

For many reasons having to do with the utilization of coke oven and blast furnace gases in steel manufacture and with the use of hot metal, the blast furnace is now usually a part of a steel producing unit which also includes coke plant and rolling mill. Both blast furnace and coke oven gas are therefore usually applicable to any of the iron and steel making processes, including the generation of power, and their allocation in any given works should be considered as a single problem. The uses to which blast furnace gas, either alone or mixed with coke oven gas may be put, include the following:

1. *The regenerative heating of air for the blast furnace*—This is the oldest and metallurgically the most important of all uses. It is universally performed with unmixed blast furnace gas and should require under proper conditions not over 23.5 per cent of the total gas generated for a blast temperature of 1350 deg. F.

2. *The use of gas for steam raising purposes*—This is almost universally done with unmixed blast furnace gas. From the standpoint of quantity used, it is at the present time the most important application in American steel works practice.

3. *The use of unmixed blast furnace gas in gas engines both for blowing and power*—While there have been large scale installations of gas engines in the United States, the use and renewal of which still continues, the tendency in recent years has been to take advantage of the marked improvement in boiler construction and operation and of increased size and efficiency in the steam turbine and to install steam driven units for

both blowing and power. Even although the present tendency is toward the use of steam, the large number of gas engines installed and the advantage of washing to a high degree of cleanness at minimum cost, makes improved methods of gas cleaning of great interest in connection with this use.

4. *The underfiring of coke ovens with blast furnace gas*—This may be carried on with either straight blast furnace gas or with a mixture of coke and blast furnace gases. The use of straight blast furnace gas for this purpose is now more than 12 years old in Germany and its application in this country has been definitely proposed, although no American plant is as yet operating under these conditions. The advantages of straight blast furnace gas include a greater ease of consequent benefit to the character of the coke. This is due to the large percentage of inerts in the products of combustion of blast furnace gas and the consequently increased length of the flame.

5. *The use of blast furnace gas mixed with coke oven gas in the manufacture of open hearth steel*—Proper use of these fuels require a variation in the percentage of coke oven gas contained in the fuel mixture in accordance with the stage of the open hearth process. No single fuel has obtained the heat economy in the open hearth which is possible with mixtures of blast furnace and coke oven gas under these circumstances.

6. *The application of blast furnace gas either alone or mixed with coke oven gas for mill heating*—The range of heating operations to which these gases have been successfully applied includes all processes from the soaking pit to sheet and pair furnaces in the sheet mill. In mill heating the proportions of the mixture are held constant for any given operation, but are varied in accordance with the temperature of the steel entering the furnace, the temperature to which it is desired to heat, the necessary speed of heating and the size of the steel.

Of these uses, application to hot blast stoves and to boilers may be made without other cleaning than that obtainable through wet scrubbers, but at the sacrifice of ultimate refinement and efficiency of operation. For open hearth and mill use as well as for stoves of refined design, a secondary fine washing has been found necessary wherever such applications of blast furnace gas have been made. In the case of gas engines and coke oven underfiring a very high degree of cleaning is necessary.

The choice of uses to which blast furnace gas should be put for the realization of the greatest possible benefit depends in great degree on local circumstances. In every case, however, decision should be made in accordance with certain broad principles. In all cases the primary use of blast furnace gas will be for regeneration of the hot blast. No economical substitute for blast furnace gas for this use has been proposed.

*Paper delivered before the American Institute of Mining and Metallurgical Engineers, February, 1928.

†Vice president, H. A. Brassert Company.

With regard to the second use listed above, that is, steam generation, it is necessary to consider that blast furnace gas with a very slight admixture of coke oven gas is a perfect substitute for producer gas, while at the same time its employment avoids the expense of producer installation and operation, and a loss in the producer which runs from 10 per cent to 25 per cent of the fuel charged in accordance as the producer gas is used hot or is cooled prior to use. On the other hand the preparation and use of solid fuel under boilers either in stokers or as powdered coal involved a less expense for installation and operation than is involved in the producer operation for the same quantity of coal. It is also to be noted that solid fuel is more economical and capable of giving a higher boiler efficiency as well as a greater production from the same boiler than is blast furnace gas. The tendency toward higher pressures and more superheat in steam will increase these differences, excepting as preheat is applied both to air and gas, the latter condition being possible of fulfillment only with finely washed gas. In general, therefore, it appears that blast furnace gas is best used in a process where gaseous fuel is recognized as necessary rather than as a substitute for solid fuel in a process in which the latter is capable of giving better results.

The other uses include the driving of gas engines, underfiring of coke ovens, and open hearth and mill heating. Insofar as gas engines are installed or may be installed for reasons, a discussion of which is beyond the scope of this paper, blast furnace gas will be allocated to this use. Such gas will be washed to the highest degree of cleanness possible.

The advisability of using blast furnace gas for underfiring coke ovens will depend upon the relative value of the two gases for other purposes. Where by-product gas can be sold to a public service company at a price which is based not only on its heat value but also on economy of transportation and convenience in use, it will be advantageous to underfire the ovens with blast furnace gas. This use also makes possible the conservation of gas at week-ends or during periods of slack demands with a holder capacity one-sixth the size of that necessary for an equal heat value contained in blast furnace gas.

Where no outside sale of coke oven gas is contemplated and where both blast furnace and coke oven gas require use within the manufacturing plant, blast furnace gas is best allocated to the steel works and the heating furnaces for use in mixture with coke oven gas. This procedure enables a special fuel best adapted to each operation to be obtained by proper proportioning of the mixture, and the thermal results obtainable are superior to those which can possibly be obtained by the use of either gas singly or by the use of producer gas. The logical order of use of blast furnace gas is accordingly as follows:

- 1—Hot blast stoves.
- 2—Gas engines where such engines exist.
- 3—Open hearth and mill heating.
- 4—Coke oven underfiring.
- 5—Use under boilers.

As stated above a certain latitude with regard to conclusion as to the relative desirability for use for steel works and mill heating and for coke ovens is necessary in accordance with the circumstances existing at any particular plant. With this exception, how-

ever, the order of uses is logical under the circumstances usually existing.

Conditions of Gas Washing

Determination of the most advantageous means possible to employ in blast furnace gas washing requires consideration of several fundamental conditions. These include the necessity of eliminating silica, alumina, lime and other slag forming materials as well as metals, particularly manganese, which exist in the hot gases as vapors, and which are condensed into finely divided fumes upon cooling. These vapors begin to condense at the temperatures existing in the mains of the gas system prior to cooling and give rise to the condition practically known as "smoky gas" which is well known to be extremely difficult to burn. The complete condensation of these vapors requires the cooling of the gas to a temperature of approximately 200 deg. F., and gas washing in the true sense can therefore not be accomplished at higher temperatures.

The necessity of cooling to 200 deg. presents a problem with regard to the advisability of further cooling in order to obtain maximum useful heat effect from a given volume of dry gas and also maximum temperature of combustion. This problem arises as a result of the inevitable inclusion of water vapor in the gases as they come from the blast furnace. This water vapor excepting as hydrogen may be formed in the upper part of the furnace, corresponds to the total content of moisture in the blast furnace charge and of combined water in the ore and possibly in the limestone, plus the water which in American practice is added to the charge for the purpose of controlling the top temperature. This water vapor will constitute at least 10 per cent by volume of the top gases and in the case of many American furnaces where water is added to the stock without exact measurement it may very considerably exceed this figure.

In considering the means proper to employ in handling this water vapor, it is advisable to point out a fallacy which has often been stated in connection with so called methods of dry washing. Advocates of these systems have claimed an advantage for such methods on account of the retention in the gas of sensible heat. Even although it were possible to wash gas completely at the temperatures at which it issues from the blast furnace top, the presence of water vapor involves a heat loss greater than any possible gain through high temperature of the gas as used. This is true for all temperatures which correspond to reasonably good blast furnace practice. It is still more true in view of the fact, as stated above, that cooling to 200 deg. F. is necessary in order to eliminate slag vapors from the gas.

Disadvantages from Moisture

Cooling to such a temperature involves a loss of much of the sensible heat originally contained, while the temperature in question is still above the dew point of the gas. It follows that the advantage of sensible heat is necessarily lost in part, while the disadvantage of water vapor content remains in full measure.

The disadvantages in use of the content of water vapor in gas cleaned above the dew point include the necessity of heating the water vapor to the temperature of combustion, which heat can only be partly recovered, in view of the higher temperatures at which

the products of combustion issue from industrial furnaces. They also include the lowering of the maximum flame temperature possible to obtain with gas of a given composition exclusive of water vapor.

A third disadvantage results from the fact that the temperature of combustion of the blast furnace gases lies within the range of temperature at which water vapor is dissociated and hydrogen formed. This decomposition of water involves a very serious heat loss which cannot be practically neutralized by subsequent combustion of the hydrogen at a lower temperature and at a later period in the heating process. Such combustion is likely to take place in the chimney flue or in the chimney itself and thereby to cause an undesirable temperature at these points.

Failure to eliminate water vapor from the gas in the washing process may also result in its condensation in the process of transmission from the washing plant to the point of combustion, with the result that liquid water is projected into the stove, boiler or other industrial furnace, and both the pyrometric effect and the recovery of heat further impaired.

It follows from the above statements that all processes of gas washing whether dry or wet which contemplate practically complete cleaning must include means for cooling the gas to the lowest practicable temperature which will usually be below 90 deg. F. At this temperature the maximum possible content of water vapor is 4.5 per cent, as compared with 10 per cent or more in gas above the dew point. The reduction in temperature and in moisture content will result in the practical attainment both of higher temperatures and of a more efficient recovery of the heat contained in a given volume of gas under circumstances otherwise the same.

Comparison of various methods and processes of gas washing including the so called wet, dry and electrical precipitation methods should therefore be predicted upon an equal degree of cooling of the gas prior to use.

It follows that both the dry filter or bag and the electrical precipitation processes are under the necessity of using an equal amount of water for cooling purposes with the so called wet method, in order to produce washed gas of equal value.

Another underlying condition which it is necessary to meet in all systems of gas washing is the economical recovery and disposition of the dust separated from the gases. The coarser particles of dust have a high metallurgical value on account of their content of iron and also of coke breeze, the latter permitting sintering without additional expense for fuel. The finer particles of flue dust are less rich in iron and are furthermore extremely difficult to sinter by present methods, this difficulty involving a reduction in the product from a given sintering plant and a deterioration in the quality of the sinter produced which, generally speaking, makes treatment by this process uneconomical. It is important, therefore, to effect, if possible, a separation between grades of dust which are capable of reuse as ore through sintering and those which are merely refuse.

The elimination of the coarser dust from the gas by processes of dry separation is also important as tending to reduce the expense incident to its recovery as wet sludge. The cooling of the gas after purification as practiced in the dry and electrical systems fulfills

this condition better than does the wet cleaning system as heretofore practiced. The development of means for effecting further separation of dust by dry methods prior to preliminary scrubbing is probably the most important improvement which can be made in wet washing methods.

The conditions of gas cleaning necessary and desirable to fulfill may in accordance with the above statements be summarized as,

1—Cooling to 200 deg. F. for the condensation of slag and metal vapors.

2—Further cooling to lowest practicable temperature for the elimination of water vapor.

3—Classification of dust in order to permit an economical recovery of contained values.

4—The reduction of the amount of dust necessary to handle as wet sludge.

Gas Washing in Europe

Much of the practical experience which has indicated the relative advantages of the various possible uses of blast furnace gas has been obtained on the Continent, and particularly in Germany, where the modern gas engine, as well as the science and art of gas washing as at present practiced, had its origin. Here economic conditions, including a high cost of fuel, forbade the use of blast furnace gas on any basis but that which afforded maximum recovery of heat value. The recognition of this necessity and the successful study of the manifold conditions involved in the solution of its problems, are in accordance with the scientific spirit which has always actuated the German iron and steel industry. The gas engine was the first important development in the direction of heat economy. Under the conditions existing, its use was immensely profitable, and its general adoption in German and Belgian iron and steel plants followed, although the use of the steam boilers still continued for the production of steam for coke ovens, for use in mills not yet electrified and for turbine driven generators installed for peak loads of power. The general adoption of the gas engine, however, made available for purposes other than blowing and power a large surplus of blast furnace gas which was applied with entire success to the underfiring of coke ovens and to use in the open hearth and in mill heating. The full development of the latter uses is the most important recent advance in heat economy.

The large scale use of gas for purposes which demanded fine cleaning led to the trial of gas equally well cleaned for stoves and boilers and to a realization of the benefits of such better cleaning. The consequence is that all blast furnace gas in Germany is given a secondary cleaning and washed gas in the American sense of gas cleaned in scrubbers only does not exist.

It is probable that this difference between the usual German practice and that common in American originated from the wide spread and permanent adoption of the gas engine in the former country 25 to 30 years ago. In the United States the practically universal use for surplus blast furnace gas has been in firing the steam boiler, and since fine cleaning of the gas for this purpose was not enforced by the conditions of operation, American development in gas washing has lagged behind. However, conditions of boiler use are now greatly changed, with the result that the

value of fine gas for boiler purposes has very greatly increased within the last few years. The pre-war boiler was a relatively simple affair, low in cost and arranged in small units. The modern steel works boiler embodies all the refinements in steam practice which have been developed as a result of the expansion of public utility installations. The development includes a quadrupling of the average size, a tripling of the steam pressure, the employment of a high degree of superheat and the use of surface condensers with evaporation of the make-up water. Such boilers cost at least \$175.00 per rated horsepower and where fired with blast furnace gas are adapted to continuous service at a high rate of evaporation in every respect but one. It is not uncommon in the steel industry to see a unit of such an installation costing over \$200,000 and equipped for continuous operation so far as its inner surfaces are concerned, which requires a daily cleaning of burners and a weekly removal of the flue dust deposited on its tubes in order to maintain the rate of efficiency upon which the justification of its cost depends. The elimination of such a condition within a short time may be confidently expected.

Secondary Washing in German Plants

The German blast furnace plant has now for many years included a complete installation for the secondary washing of the entire production of blast furnace gas with the same regularity that it has included blowing engines and hot blast stoves. These washing installations are adequate in size and are constructed in accordance with the same generally high standards of engineering which characterize the remainder of the equipment, and they form no small and inconsiderable portion of the blast furnace plant.

The usual practice is to provide a dry dust catcher for each furnace and to concentrate all subsequent cleaning equipment into one central installation which handles all the gas produced by the plant. The dry dust catchers are usually very much larger than is the corresponding equipment in America and the centralization of gas cleaning results in the erection and use of long gas mains. The total cost of installations of equal capacity vary considerably in accordance with the length of mains, the system of cleaning employed, the character of construction and size of the plant. Excluding dust catchers and collecting and distributing mains, the cost of gas washing plant per 100 tons of pig iron capacity per day is at least \$12,500. This corresponds to an investment of \$375,000 in a plant of 3000 tons daily capacity.

The operating costs are usually from \$.00177 to \$.00283 per 1000 cu. ft. of gas. This corresponds approximately to an operating expense of from \$.225 to \$.40 per ton of pig iron. No matter what the system of cleaning employed, there is nothing perfunctory about the gas washing operation. On the contrary it is carried on with the same regard to essential details which characterizes the operation of the gas engine. The amount of supervision varies in accordance with the system employed. In the case of wet washing by the disintegrator method but little attention is required, aside from the regulation of volume of water employed in accordance with the temperature and quantity of the gas and the temperature of the water. In the case of systems which employ either bag cleaning or electrical precipitation a very careful regulation of temperature, degree of saturation and of pressures

throughout the gas cleaning system is necessary. All of these requirements are faithfully carried out by thoroughly trained men. This care and operation and the expense which it involves, as well as the size and cost of the installations indicate how thoroughly the Continental iron and steel makers believe in the benefits derived from fine cleaning.

Results from Fine Gas Cleaning

The primary general result obtained through this fine gas cleaning is the ability to refine and control every operation in which the gas is subsequently used. Avoidance of the nuisance and expense of removal of dust from combustion chambers and furnaces in which the gas is burned is secondary. The refinement of all the processes of combustion and use involves other elements than merely the cleaning of the gas, and the remarkable results in the direction of heat economy which have been attained abroad are due to a complete system which includes careful design of furnaces, improved methods of combustion, accurate measurements of pressures and quantities and gas analyses. These refinements are only possible to practice with equipment, the condition of which is permanently good, and in which rapid change of conditions due to fouling of apertures, fluxing and disintegration of brick work and other numerous irregularities which attend the use of semi-washed gas do not occur.

Many attempts at refinement of practice in American plants under the latter conditions have come to nothing on account of the fact that the semi-washed gas made conditions of operation impossible to control. Operation of the steam boiler in this country may be cited as an example. If such a boiler is equipped with one of the numerous burners which depend for accurate mixing of gas and air on the relative size of orifices, this relative size is disturbed by accumulation of mud in the burners. A regulator provided for the maintenance of a given pressure in the combustion chamber and set for a clean burner works improperly after the burner is fouled. The conductivity of heating surfaces become impaired and the rate of feed and the drop in pressure through the boiler show a progressive variation from the conditions contemplated in the design. The use of preheat for the gas, which would otherwise have come into general use many years ago has proven impracticable on account of the excessive amount of attendance in cleaning which the preheater requires and of the progressive reduction in the amount of preheat obtained as the surfaces become coated. Every relation of one part of the system to the other is disturbed and the net loss is many times greater than that represented by the cost of periodical dirt removal from the system.

Where fine cleaning of gas is employed, the situation is exactly the reverse. The mechanical conditions within the system including size of orifices, conductivity of refractory surfaces, frictional resistance and direction and intensity of gas currents are constant, and the conditions of operation are capable of continuous study and gradual improvement. This study is faithfully and carefully given. The observation and regulation of one condition makes possible the estimation of the value of the results to be obtained by further regulation. Close study of these conditions has in many plants resulted in a system of operation in which avoidable losses are practically eliminated.

Regulation and Control

Hot blast stove operation as often practiced on the Continent is one of many examples which may be cited to show the extent to which regulation and control is practiced. The control apparatus includes flow meters for gas and for air for combustion and for cold blast to the stove. The stove main is held under constant pressure. The chimney draft is automatically regulated. The waste gases are analyzed and the CO_2 , as well as the sum of the CO and H in the waste gases is automatically indicated. Under these conditions every variable which can effect the accuracy of the combustion or the degree of heat absorption by the stove is known and the stove efficiency without allowance for radiation may be calculated at any time from contemporary data. Under these conditions the waste gas temperature is often as low as 400 deg. F., the combustion is nearly perfect and the calculated efficiency of the stove without allowance for radiation is about 85 per cent.

The benefit of washed gas is also shown by a practical permanence of the stove construction. In one case a set of stoves has operated for 10 years without repairs, in another, necessary repairs to checkers amounted to 3 ft. of brickwork after three campaigns.

Where gas is used under boilers it is universally cleaned to a point where clogging of surfaces does not occur. Under these conditions and with skillful control, the boiler efficiency is constant and relatively very high. The results include a complete freedom from interruptions on account of either inner or outer tube surfaces.

The large use of gas for driving engines and for underfiring coke ovens permits no argument as to the desirability of gas washing since both of these uses require gas of the highest possible purity.

Blast Furnace Gas for Open Hearth Furnace

Another use of washed blast furnace gas which is of extreme interest in America, is its application in a mixture with coke oven gas to the manufacture of open hearth steel. In several of the best German plants the overall consumption of fuel in the open hearth is less than 4,000,000 Btu. per metric ton of steel. The actual consumption during the busy part of the week when operations are proceeding is from 3,360,000 to 3,600,000 Btu. This low rate of use of fuel is accompanied by a remarkable speed in operation. At one plant 70-ton heats made with 70 per cent scrap and 30 per cent pig iron are being regularly made in six hours. In another plant heats of 180 tons are being made in eight hours with 75 per cent of scrap. The quality of steel at both of these plants is exceptionally good. These results are obtained by a varying proportion in the mixture of blast furnace and coke oven gas, the coke oven gas running from 22 to 42 per cent of the mixture and the Btu. per cubic foot from 186 to 279. The higher heat value is used during the period of melting and the lower during the boil and while finishing. The furnace is thus forced when necessary and heat is saved during the time when it is not needed, while at the same time a sufficient volume of products of combustion is available to maintain the proper working pressures within the furnace. This condition cannot be fulfilled while working with straight coke oven gas without waste of fuel and the ability to introduce a large volume of gas of

low calorific power and thus maintain the proper working conditions in the furnace is extremely valuable. Other conditions of operation, including close control, a high degree of regeneration of gas and of air and certain details of the furnace construction contribute to the result. The most important factor is, however, the use at all times of a gas exactly suitable to the temporarily existing conditions.

As applied to mill heating, results equally remarkable with those of the open hearth are being obtained. The consumption of gas in soaking pits used in connection with the rolling of open hearth steel is about 100 lbs. coal equivalent per ton of blooms, and heating operations in continuous furnaces require practically the same amount. These results are obtained in furnaces of good design and under skillful operation. The remarkable results are, however, largely due to the use of a carefully predetermined mixture of coke oven gas with fine cleaned blast furnace gas.

The situation of the iron and steel industry in Germany after the war was one which required the utmost possible effort in the direction of economical use of resources. The circumstances of shortage of working capital combined with slack demand led to an intensive study of all conditions affecting the use of fuel and the adoption of the best possible means for its realization.

Economies

As a result of this intensive study of available means for the better application of by-product gases and of waste heat from gas engines, there are several plants in Germany in which no coal excepting that used at the coke oven is employed for mill purposes, including transportation within the works. An exception to this is to be noted in the case of narrow gauge locomotives operating within the steel works buildings where for reasons of convenience and safety steam is still employed. The possibility of completely avoiding the use of coal is based in part on the manufacture of steel by the Basic Bessemer process. It is, nevertheless, a very remarkable achievement in thermal economy. The results have been particularly notable within the last five years within which time the consumption of coal for auxiliary purposes has within these works been reduced from 1100 lbs. per ton of finished product to practically nothing. The total estimated saving to the German steel industry produced by the adoption of better methods of fuel use is 200,000,000 gold marks per year. These economies may be said to have been produced almost entirely by more skillful methods in the use of blast furnace and coke oven gas, the use of the blast furnace gas requiring in every case a secondary washing.

The standard of cleanness in German practice permits a maximum content of dust in gas of .04 grains per cubic foot of gas. This corresponds to the limit of cleaning possible with the fan installations which are still used on a considerable scale for the washing of gas for stoves, boilers and heating furnaces. A higher degree of cleanness is considered preferable even by those operators who are continuing to use the fans. However, in Germany, as elsewhere, an installation once made is difficult to replace so long as operation is possible with the existing facility. Gas cleaned by either the disintegrator or the Halberger-Beth system of bag filters may be brought to .002

(Continued on page 488)

Manufacture of Steel for the New Ford

Outlines the Open-Hearth, Ingot Casting and Soaking Pit Operations—Comments on Fuel Used and Methods of Combustion—Transfer of Ingots to the Mill

By J. B. NEALEY*

STEEL for the Ford automobile is made in one of the world's most modern steel plants which is located at the Fordson plant of the Ford Motor Company. Here are seven 100-ton open-hearth furnaces of which four are of the tilting type and two of the stationary type. These units are 70 ft. long and 22 ft. wide.

The building housing the open-hearths is divided into three bays to accommodate the stockhouse, charging floor and pouring aisle respectively. The stockhouse is served with a 15-ton traveling crane and two of 10 tons capacity each.

Ladles of molten pig iron are brought in from the blast furnaces, emptied into a 600-ton hot metal mixer

and the mixer metal conveyed to the open-hearths in a 65-ton ladle. Overhead bins carry the limestone, ferroalloys, fluorspar, iron ore and dolomite and discharge directly into charging boxes which are hauled by locomotive on tracks to the open-hearths.

A gas burner with a 5 in. water-cooled nozzle fires directly above the hearth of each furnace from either side. The checkers or regenerators occupy the 25-ft. space between the charging floor and the pouring aisle. Every 15 minutes one burner is automatically shut off and the other lighted, the hot gases being forced across the hearth by draft and down through one of the regenerators, to which they impart much of their heat to the brick checkers. The waste gases are then exhausted into the air through a brick lined stack 175 ft. in height.

*American Gas Association.

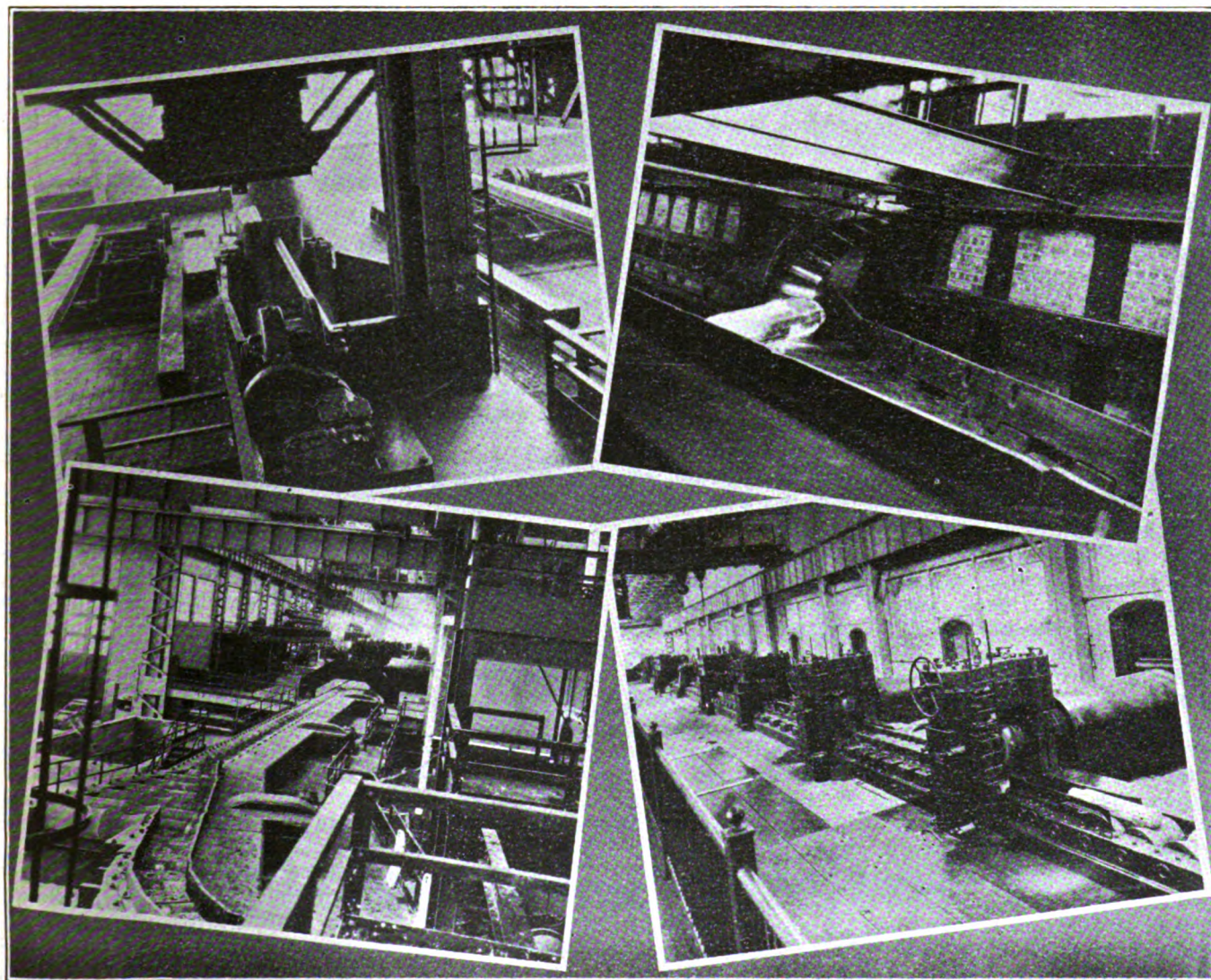


FIG. 1 (upper left)—View at soaking pits where ingots enter the chute. FIG. 2 (upper right)—Chute from pits to mill tables. FIG. 3 (lower left)—Conveyor tables from chute to mill. FIG. 4 (lower right)—Ingot entering mill.

Fresh air for combustion is drawn in through the other regenerator and by the time it passes the burner nozzle and mingles with the gas, it is so hot that it does not materially cool the hearth. It requires from six to seven hours to bring the temperature of the open hearths up to 2900 or 3000 deg. F. and the steel is ready for pouring in 11 to 13 hours. The waste gases enter the stack at 1200 and leaves it at 600 deg. F.

The pouring aisle is served with two 175-ton traveling cranes and the steel is tapped directly into a 120-ton ladle suspended from one of them. A train of molds, hauled by a locomotive, on tracks running parallel with the open hearths is pulled into position under the ladle. A pouring pan with four nozzles is placed in position between the ladle and molds so that four molds can be poured simultaneously.

One heat requires about 120 molds and the ingots each weigh approximately 1680 lbs. The slag is handled in thimbles holding 250 cu. ft. each and these are mounted on trucks operated on the tracks in the pouring aisle.

The mold train is next run into the stripper room where the ingots are loosened in the molds by a battery of eight rams. The train is then spotted alongside the soaking pits and the ingots charged into the pit furnaces by crane.

The Soaking Pits

The soaking pits, for the equalization of temperature throughout the ingot prior to the breakdown in the rolling mill, are arranged in six blocks, each block containing four holes. Each of these holes or hearths is constructed with regenerators or brick checkers on each side. Together with the checkers the hearths are 45 ft. wide and will hold from 12 to 18 ingots at a charge.

The depth of the hearths vary from 5½ to 9½ ft., while the total depth, from top of hearth to the bottom of the tunnels below the checker level, is 21 ft. Each block is as long as the hearth and checkers are wide, and the four holes are so placed as to give a combined width of 36½ ft. The checkers in cross section are 4½ ft. while the depth is 10½ ft.

The fuel used in these soaking pits is gas which is fired directly into the hearth through burners located on either side. These burners consist of a manifold 6 ft. long and 3 in. in diameter but terminate in a plug with an aperture of only 1½ in. Gas is supplied at 10 lb. pressure, but is reduced to 6 oz. in the manifold.

In accordance with standard practice only one burner fires at a time. A tunnel containing a double flue for each block of four holes is equipped with a butterfly valve for each hole. The operation of this valve reverses the flow of fresh air and products of combustion every 10 minutes, the first flowing through the heated checkers and to one of the burners while the latter is drawn through the other checkers, which it heats, and then on out through the stack. The firing from the burners is also changed with the reversal of the draft. These soaking pits are operated at a temperature of about 2000 deg. F. and the soaking periods vary from 2½ hours to 3½ hours according to the size and composition of the ingots.

As the hot gases pass from the hearth to the checkers they drop from 2500 to 2000 deg. F. The checkers are heated to 1600 deg., on an average, and the draft leaves them at about 1000 deg. F. The temperature of these gases drops another 100 or 200 deg. in the tunnel and the flue or stack gases range from 700 to 800 deg. F.

Extra precautions against waste of heat through radiation have been taken in the form of special brick and other insulation, which has raised the thermal efficiency of these units materially. The hearth and regenerative chambers are lined with No. 1 fire brick backed with a layer of Sil-O-Cel brick and covered with wire cut brick. This latter is omitted in the case of the roof of the hearth. The hearth floor, which is supported by cast iron pillars and a framework of steel beams, is lined with No. 1 fire brick. The tunnel floors are also lined with this grade of brick resting on concrete.

Insulation in the form of C3-tin clay and silicate of soda has recently been provided for these covers which is a material improvement over non-insulated covers.

Ingot Conveyors

After a uniform temperature has been obtained throughout the ingots are then lifted by the same cranes and placed in a chute which drops them into a gravity conveyor going direct to the 42-in. blooming mill. This chute supplants a tilter, which was formerly used, thereby eliminating a motor and an operator. The gravity conveyor is also a big improvement as it cuts crane and labor costs.

Deoxidation of Iron with Manganese

(Continued from page 481)

If this theory be valid it means that as a deoxidizer, manganese does a great deal more than simple reduction of iron oxide by the well-known reaction:



This is probably the first step. It is then followed by the formation of a slag of FeO and MnO in which the activity of the FeO is very much less than in ordinary basic slags. Consequently, to establish equilibrium between this slag of deoxidation products and the metal in which it is temporarily suspended, more FeO must pass from metal to slag with the result that the bath is cleaned of considerably more oxide than the manganese of itself can account for.

The Cleaning of Blast Furnace Gas

(Continued from page 486)

grains per cubic foot. The degree of cleanness is fixed in the case of the bag system. With the disintegrator the degree of cleanness may vary from the figure given above up to .009 in accordance with the method of operation. Fine gas as understood in Germany, has a content of dust below this latter figure. Standard practice requires the best cleaning of which the disintegrator or the Halberger-Beth apparatus is capable where the gas is to be used in engines or in coke oven underfiring. There is a very strong disposition to insist on an equal degree of cleanness for gas used in open hearths and in mill heating. Progressive operators are practically unanimous in the opinion that cleaning to a less degree of fineness than .009 is not economical in view of the fact that the cost of the finer washing by the disintegrator may now be reduced to a figure practically the same as that of the less perfect cleaning accomplished by the older fan installations which still have a very considerable use.

(To be continued)

Sheet Steel for Automobile Bodies

Outlines the Rolling of Sheet Bar and the Passes Used—Describes Defects which Affect the Finished Sheet—Discusses the Relation of Gage and Bar Weights and the Chemical Variations

"AUTOSHEET"

PART II

HAVING reduced our 20 in. x 20 in. ingot to a 4 in. x 6 in. bloom we are now ready to reduce it to sheet bar stock on a sheet bar mill. The sheet bar mill may be only one roll having six or seven grooves capable of bringing the bloom down to a sheet bar which is usually 8 in. wide and of varying thickness, or it may perhaps be a set of four or five rolls in line or tandem. For simplicity we will consider the sheet bar made on one roll as tandem or continuous bar mills require more space and equipment.

The heat of our 20 in. x 20 in. ingot from the soaking pit has gradually dropped and at this point the bloom must be immediately sent on to the sheet bar mill or reheated.

The question of reheating depends entirely upon the rate or speed of rolling to a bloom, the ingot's initial temperature from the pit and the readiness of the sheet bar mills to take this hot bloom. A steel mill rolling sheet steel exclusively will take this bloom on to the sheet bar mill without reheating, while a mill rolling a variety of products may stock the blooms. In this particular case we will immediately send it along without reheating for reheating involves equipment and fuel which increases the cost of the ultimate sheet.

Design of Sheet Bar Rolls

To simplify the explanation of how this 4 in. x 6 in. bloom is reduced to sheet bar, Fig. 1 shows the reducing grooves set in the top roll together with their position to the bottom roll. A cursory examination of these rolls show that they are quite different from our blooming roll which demands an explanation.

It is primarily our aim to produce a sheet bar exact in dimensions and due to its thinness as compared to its width it is to be expected that varying widths, wavy sides and uneven thickness will cause us the most trouble. As has been noted before in rolling blooms or billets we were able to eliminate this trouble by occasionally "edging" or turning the ingot on its side which allowed us to iron out the fins or side spread of the metal brought about through previous passes. However edging is practically impossible now that we have materially reduced the thickness and increased our width. To better control this width, variation and wavy sides, grooves and tapered sides as shown in Fig. 1 are necessary.

This type of rolling is called box or "tongue and groove" passing the groove of the top roll forming one side of the sheet bar and the two edges forming the two sides of the bar while the "tongue" of the bottom roll closes up the bottom or fourth side. It should be noted that the sides of the groove on the top are slightly tapered which allow a close fit to the tongue of the lower roll thus holding the metal within the "box."

As a general rule there are six or seven reductions to a definite size before the resulting sheet bar is run out onto the cooling table as finished. These passes are made as quickly as possible and it is therefore necessary that the reduction of the bloom be quite pronounced, better illustrated in Fig. 2 which shows the cross sections under varying passes from a 4 in. x 6 in. bloom to sheet bar 8 in. wide and $\frac{1}{2}$ in. thick. There are several passes in each groove all depending upon the temperature of the bar while between re-

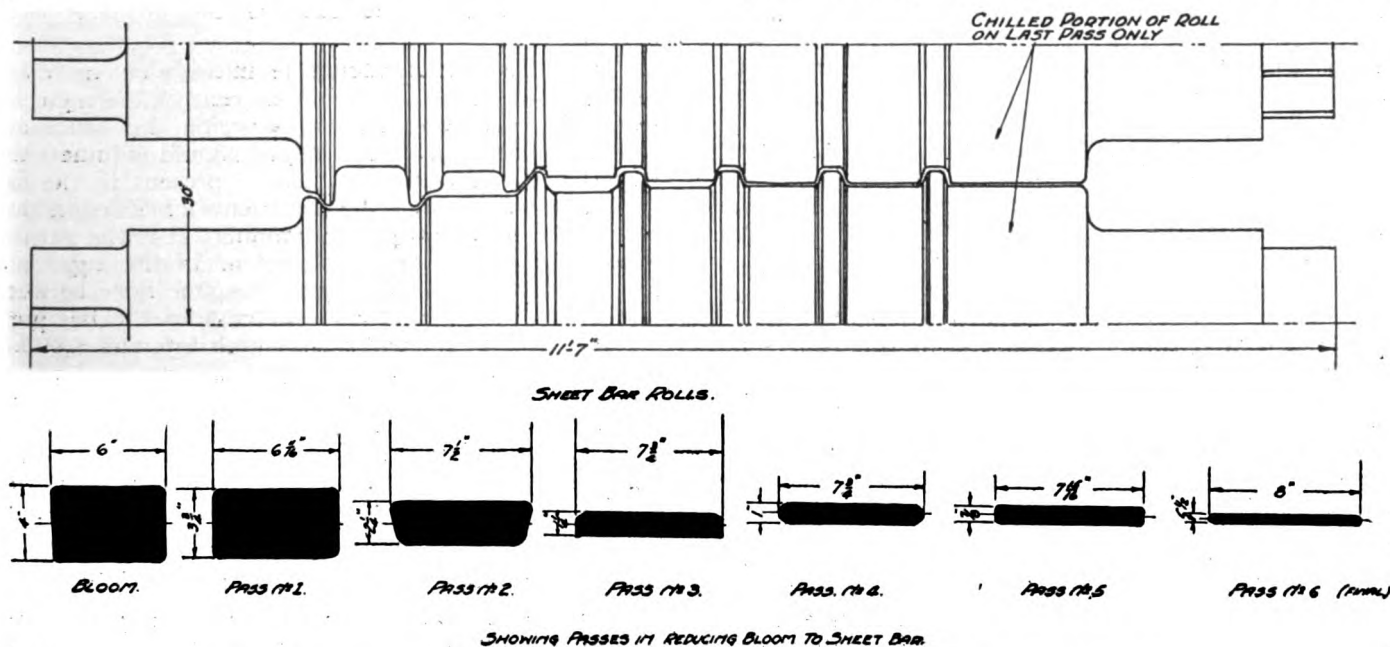


FIG. 1 (upper)—Sheet bar rolls. FIG. 2 (lower)—Passes from bloom to sheet bar.

ductions of one groove to the other the bar is turned 180 deg. on the table by steel fingers thus eliminating any slight fin on the edge of the bar which, in spite of the closed pass, may form through worn or ill fitting rolls. The final pass before finishing is made through a chilled roll or a chilled portion of one roll in order to give the bar a smooth surface. As the edges of the bar are not held on this pass they become slightly rounded or what is known as a "mill edge."

Throughout the rolling on the sheet bar mill the bar is sprayed by water under hydraulic pressure in the same manner as on the bloom mill to remove the scale. The spray jets are usually a foot or two away from the roll and spray both the under and top side of the bar.

Surface Defects of Bloom and Sheet Bar

The sheet bar is now finished and ready to be sheared to stock sizes or into definite lengths for immediate working on the hot mills. In running out onto the cooling table the sheets are checked for the thickness specified and for surface defects. Before progressing further we should discuss a few outstanding surface defects which may be found by visual inspection. While a great many defects have been previously discussed various intervening operations have removed some of these defects and introduced others and in the study of automobile body sheets not only are we concerned in its drawability, but its surface as well and a constant check on surface is not really out of place.

Our first and most important defect for this semi-finished product is the rough or pitted surface of the bar usually due to two things. First the failure to remove the scale during rolling which, adhering to the metal, leaves an impression or pit containing a considerable amount of oxide. This defect becomes very noticeable when either the sheet bar or the breakdown (first hot rolling of bar) have been pickled in a dilute acid as a test for the marked presence of this and similar surface defects. If the pits are light subsequent rolling will usually close them up. Another cause for pitted or rough surface is due to the opening of blowholes close to the surface of the bar either in its soak or rolling. This, as previously explained, causes oxidation of these blowholes and results in "seams." Expansion of a gas pocket just under the surface of the steel will show up as a "blister."

A tearing of the corners of a bloom or sheet bar will cause "slivers" which are brought about from improper pouring of the steel into the moulds and oxidation or burning of the steel in the open hearth.

"Cobbling," while not going further than our bar mill, is worthy of note as it is a frequent occurrence. Cobbling is a catching or buckling of the bloom or sheet bar either in the rolls or on the runout table and usually results in a scrapping of a portion if not all of the bloom, being rolled. A defect which occurs in the rolling of the sheet bar and which follows through to the finished sheet is unequal draft on the rolls which results in the end of the finished sheet being light to the gage specified. Unequal draft is caused by one roll not being parallel to the other roll thus giving the bar a heavy side. This heavy side then becomes a heavy end of the finished sheet which is very undesirable for drawing in dies whose clearance of course does not allow for this heavy end and usually will cause breakage in that portion of the sheet. This defect

rarely occurs as the bars are constantly being measured for thickness as they come off the finishing pass of the bar mill.

In the rolling of blooms and sheet bar it is not uncommon to occasionally get ingots or blooms which do not flow evenly under the draught or pressure of the rolls and as a result tear or split open slightly. These openings in the steel are readily oxidized and in the following passes are closed up and escape detection even in pickling and occasionally in the final sheet inspection. This inclosed defect is quite often the cause of breakage; an example of which will be discussed later.

However, such defects are not explainable until a microscopical examination of the steel at the point of fracture reveals streaks of oxide which is the oxidized surface exposed in cracking. There are several theories advanced for the cause of this defect and while the draft on the material is too often blamed, the carbon and manganese content of the steel, the method of preheating the ingot, burnt steel, and failure to turn often enough in rolling, are other contending factors.

Shearing the sheet bar into the specified length, while seemingly simple, presents defects which are injurious to the further mechanical treatment of the steel. Sheet bars must present a clean cut edge with as little burr or "lip" as possible as this burr will mark the hot mill rolls. A heavy burr or "lip" usually comes from a dull shear knife or one that has too great a clearance between it and the supporting blade thus dragging the end of the cut into this excessive clearance.

In many cases it is not the fault of the shear blades or their clearance, but in the ingot itself. A spongy or soft centered ingot or a highly segregated section will be so soft as to "drag" thus throwing this objectionable burr. While it is not always possible to eliminate the burr, as formed by a spongy ingot, we have no excuse for burr on a section of the ingot which is piped or heavy in impurities.

As mentioned before the top section of the ingot, after cooled in the open-hearth pit, shows the top center to be filled with the steel last to be solidified and hence rich in impurities, such as, sulphur and phosphorus.

This piped section should be entirely cut or "cropped" off and usually 5 to 10 per cent of the ingot by weight is discarded before bars for the order are sheared. Ten per cent by weight should eliminate the worst of the impurities which, if present in the finished automobile body sheet, presents a brittleness that readily causes breakage in stamping. It is the general practice to shear this piped portion of the ingot into small sections until the heavy drag or burr between blades has disappeared and the edge of the bar presents a clean cut. If portions of both top, and possibly some of the bottom of the ingot, are cropped before rolling to bloom or sheet bar, 5 per cent represents the average cropping at the bar mill shears while if little or no cropping is done during rolling a 10 per cent crop is not uncommon or exceptional for this semi-finished product which is to be so particular in all respects before finished.

Determination of Gage and Bar Weights

Previous to 1893 there was no uniform gage to represent the different thickness of sheets; and as a result misunderstanding between sheet mills and the

consumer were not uncommon. In order to avoid such misunderstandings a table of scaled gages for sheet steel was established by an act of Congress in that year; a scale which has been universally adopted and known as U.S.S. (United States Standard) gage. This particular gage scale designated that a sheet of steel 1 ft. square and 1 in. thick should weight 640 oz. With this as a basis a scale was arranged so that each distinctive gage represents a certain number of ounces in weight and a certain multiple of 640ths of an inch in thickness.

At that time a 28-gage sheet was used as a basis of gage for black sheets which was $1/640$ of an inch thick and weighed 10 oz. to a sq. ft. From that time on various base gages were adopted for various sheet products, and at the present time we have a 20-gage black sheet as a base gage for auto body sheet steel which weighs 24 oz. or $1-5/10$ lbs. to a sq. ft. Therefore, having determined the gage or thickness of the sheet by its weight per square foot, we are now in a position to figure the weight of a sheet bar which, when rolled to a specified width and length, will give us the gage as ordered. To better illustrate this let us take a bar which is to be rolled into 20 gage 36 in. x 120 in. The first factor to be considered is the width of the finished sheet which in this case is 36 in. and to make due allowance for the side scrap or the trimming after rolling at the hot mill, we must add approximately $1\frac{1}{2}$ in. thus making the length of the bar $37\frac{1}{2}$ in. The finished 20 gage (.375 in.) 36 in. x 120 in. must weigh 45 lbs. if we anticipate getting the gage uniform and within the decimal gage of .0375 with plus and minus .003 in. for hot rolling tolerances. This 45 lb. weight does not include the side scrap previously mentioned or the scrap which must be sheared from the end of the sheet. We have already allowed $1\frac{1}{2}$ in. extra for the 36 in. wide sheet and in proportion we should allow about 5 in. for the end scrap. A total of these allowances theoretically shows that the sheet should measure, before shearing, $37\frac{1}{2}$ in. wide and 125 in. long; weighing 50.1 lb. which should be the weight of the bar when sheared. Practically all sheet bars are rolled 8 in. wide and from this it can easily be figured what the thickness of the bar must be after cut $38\frac{1}{2}$ in. long and weighing 50.1 lbs. From the above example it can be briefly summerized that the thickness of these bars will vary according to the gage and the length of the sheet to be made from them. In mill terms this is specified in pounds, per linear or "running" feet, and will range from 8 to 60 lbs.

Sheet mills who handle a great many small orders find it to their advantage to stock bars of various weights and lengths for standard sizes; but for a mill continuously rolling special grades such as auto body steel which, as mentioned before, are usually from 18 to 20 gage exclusively, stock items are not so necessary.

Having determined the size to be rolled and making due allowance for side and end scrap, we are now ready to cut the bar to length. The length of the bar will be the specified width of the sheet with due allowance of $\frac{7}{8}$ in. to $1\frac{1}{2}$ in. for the side scrap, depending on its width. It is usually the general practice to occasionally check the width, length, thickness and even the weight of the bars as they are cut in order to be absolutely sure that the hot mill is receiving a sufficient weight of steel to get the correct gage. This is a very important factor inasmuch as the only means of determining the gage of sheets is by the length to

which the sheet is rolled out on the hot mill. As the bars are sheared to length they are usually quenched in water. They are then racked or piled on skids and sent to the reheating furnaces at the hot mill.

Chemical Variation of Sheet Bar

Before concluding our discussion of the mechanical treatment of sheet bars it would not be out of place to mention the variation of carbon content of the ingot and hence in its subsequent bar. Shear tests at the bar mill repeatedly show that the carbon content is higher in the top of the ingot than in either the middle or bottom. Thus a specified .10 per cent carbon steel whose ladle analysis also shows .10 per cent will show from test bars taken at the shear that the top next to the cropping will run .11 per cent to .115 per cent carbon; the middle of original ingot will run .10 per cent to .105 per cent with the bottom of the same ingot running .090-.098 per cent carbon.

This slight variation in carbon content may, in the case of our low carbon auto sheets, be of sufficient variation to cause a slight difference in physical properties in spite of the fact that all received the same treatment. While the physical variation will be slight it serves to illustrate that such tests as taken from the shipment for chemical and physical analysis and which in a great many steel specifications determine its acceptance or rejection, may represent either the maximum or minimum of the physical properties present. As an example a test sheet might have come from a bar, cut close to the top of the ingot and having the highest carbon content will perhaps show a high hardness test, high tensile strength and low ductility while the sheet next to it may have come from a bar cut near the bottom of the ingot, showing a lower carbon content and hence a lower hardness and tensile strength and higher ductility than the previous sheet. Both sheets were processed identically, but the bars from the top and bottom of the ingot were mixed in their processing. This variation in carbon content and subsequent variation in physical properties presents a problem not easily remedied by the mill, but which must be considered by the consumer. The logical solution for this is the specifying of the order's acceptance or rejecting not entirely on its properties, but on its performance in the press or on the part intended as well.

(To be continued)

STATEMENT OF THE OWNERSHIP, MANAGEMENT, ETC., OF

The Blast Furnace Steel Plant

(Required by the Act of Congress of August 24, 1912)

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DONALD N. WATKINS, Business Manager.

Sworn to and subscribed before me this 22nd day of March, 1928.

CHAS. A. SEIBERT, Notary Public.

(My commission expires March 8, 1931.)

Blast Furnace Operation Abroad*

Mixtures of Ores Used with Large Lumps and Sintered Fines—
Limestone and Coke—Arrangement for Handling Stock—
General Furnace Design and Production Attained

By F. H. WILLCOX†

THE raw materials used in the Ruhr District of Germany are assembled from Newfoundland, Sweden, Spain, Africa, and from the Minette mines of France and Luxembourg. Perhaps 20 per cent of the raw materials originate in Germany. While the steel capacity of recent installations is largely open hearth furnaces, usually tilting type, there remains a heavy preponderance of Thomas converter capacity, and the major part of the iron production is Thomas quality. The basic iron for open hearth work is very high manganese, up to 4 per cent, always over 2.5 per cent as far as observed. This is because they concentrate practically all their scrap into the open hearth, where the pig iron charge is about 25 per cent, the remainder being good plant scrap from mills and pits, with a major part being rather poor light outside scrap. So the high scrap heat, with its low iron content, melts down with about a 1 per cent manganese, about the same starting point as with our 50 per cent hot metal of 2 per cent manganese content open hearth practice, and is tapped with the same residual manganese. Manganiferous ore is nil in Germany. They import all of the manganese and conserve it, reusing open-hearth slag and mining old ferro and even spiegel slag. This is concentrated, and so-called slag concentrate—running 12 per cent manganese—is recharged. Manganese ore comes from Sweden, Africa, and the Near East. Other common grades of iron are foundry, called hematite and of the same variable analysis that we find here.

The Mixture of Ores

With such wide sources of supply the burdens found at various plants are of the most composite character. An inland plant used a burden made up of 40 per cent Wabana, 20 per cent high grade lump Minette, and 40 per cent roasted and sintered German spathic and limonite ores, together with the usual plant by-products. Going over toward Dortmund, one large plant was using 85 per cent Swedish magnetites, about 40 per cent sintered with the remainder made up of manganese ore and plant by-products, while at an adjacent operation Wabana made up the major part of the burden. At Bochum, with four furnaces, the burden was made up of sinter, produced from a mixture of flue dust, Spanish, African and Swedish concentrates, all fines, mixed with from 8 to 12 per cent coke braze and sintered on Dwight-Lloyds. The Swedish would correspond roughly to our Harmony concentrates in fineness, but the hematites were seemingly as fine as flour.

The turn toward imported ores has given the Ruhr District a distinctly better grade ore to work with than was the case formerly. It gives a distinctly superior burden, as compared with our somewhat easily reducible ore burdens, the magnetites, sinters

and probably Wabanas not being so quickly affected by the reducing influence of the furnace gas. There seems not to be any definite proportion of sinter, hard ores or magnetic ores that gives the smoothly working furnaces which characterize the Ruhr District. In this respect their practice follows that of our eastern district where mixtures have been used for many years ranging from 20 per cent sintered ores and 80 per cent hematite, up to 85 per cent sintered ores and 15 per cent hematite, not to mention the 100 per cent sintered ore practice. Such burdens invariably give lower blast pressures, lower coke and greater regularity, the furnace taking heat—even on unfavorable lines—without serious tendency to stick and hang.

Large Lumps Used

Aside from the reducibility factor of mixed ores such as are used, the burden is of course more open, as charged. The Minettes break up and decrepitate, but with a considerable portion of lump ore, agglomerate and sinter, the burden stays more open than ours. It is in line to remark at this point that some plants having a multiple track stock house charge the ore in group filling sequence, much as is done at Provo, Utah, thereby giving a layer filling of coarse and fine in sequence.

They use some ores in a lumpy condition that we would refuse to charge. In two plants we are designing for Germany we have to provide clearance in the throat for 14 in. lumps. It is surprising that their furnaces work as well as they do. It is again surprising, at first glance, that working with a burden naturally coarse, they show as much interest in rendering fine ores coarser. The fear of fine ores is well founded because many plants where the tonnage has been brought up are blown by gas engines that cannot keep the volume up with much over 15 lb. blast pressure. Moreover, the production of Thomas iron, with its lower silicon, is more sensitive, high blast pressure has to be avoided. Also, they have materials that naturally have to be agglomerated, nodulized or sintered. Some of the Spanish and Algerian ores are finer than any we have to contend with and are as dry as a bone, and then there are large quantities of undesirable grades, like pyritic residue and spathic ore, that have to be treated.

Sintering Fine Ores

I was advised that it is not as easy to sinter fine African hematite ores as a mixture of hematite and magnetite. The tonnage in the Dwight-Lloyd machine drops off by 20 per cent. However, their Dwight-Lloyds are not as well laid out as are certain of our sintering plants with respect to return of screenings for admixture with the fine ores. They often have good preparation plants for the mixture of ores, the different components being weighed in correct proportion, put through a concrete type mixer before being charged on the machine. As compared with rate

*Abstract of an address before the Eastern States Blast Furnace & Coke Corporation, Pittsburgh, February 17.

†Vice president, Freyn Engineering Company.

of production here, they run slower on a ton per square foot per day basis. Their cost is stated to be \$0.35 per ton.

While we in America have come to like, or at least, tolerate, fine ores, and have developed furnace lines, fuel, blowers and charging equipment to fine natural ores, the Ruhr district has clung to coarse ores, natural or artificial, and this is all logical, since after we had set a pace in tonnage output and coke economy, the only way that the Ruhr district could follow, with their low pressure blowing equipment and inflexible tub charging system, was to keep the burden open.

Limestone and Coke

The limestone is usually calcite and we would call it dirty and excessively large. Since one sees all kinds and conditions of stone, it is difficult to give a general statement. But if we crush to pass all stone through a 5 in. ring, giving an average 5 in. piece, their stone will average a 6 or 7 in. piece, with maximum up to 12 in., lump and slabs. It would give an erratic distribution with our top and relatively small charges. The stone is not so free of fines, however, as a result of not as intensive crushing, as might be expected.

Leaving aside an exception here and there, their coke is not as well prepared, being more irregular in size, more irregular in analysis and moisture. As another general proposition, the Ruhr coals do not seem to produce a by-product coke that is as dense and incombustible as is still the case with many of our coal and oven operations, and one finds a distinctly larger coke in use than I see here. However, the coke is certainly not as soft and friable as their care in handling it would lead one to suppose. Their freedom from high blast pressures, hanging and slipping, also indicates a coke that holds up and burns lively. From data I secured, the coke will average 30 lb. per cu. ft., and sometimes 32 lb. Ash and sulphur are 8-9 per cent, with 1.0-1.3 per cent sulphur and 4-8 per cent moisture. There is remarkable absence of fingery coke and cross fracture, and the coke does not break up easily. The structure seems close but regular, and little of sponge or pebble. Ruhr coke is excellent, regardless of irregularity in size and moisture, and probably not as reactive to furnace variations as much of ours.

Scrap and Flue Dust

Scrap is not used to the extent that one encounters here. Much of the borings and turnings are briquetted for open hearth, or even foundry use, thereby eliminating this large source of supply. Flue dust is not recharged raw, except at one plant of nine I visited, where it is put back in to the extent of 5 per cent. They were, however, installing a Greenawalt plant. One plant was blowing the dust back in, 45 ft. beneath the top, or say 30 ft. below the stockline, in a single 3 in. opening. They use clean blast-furnace gas, compressed to 60 lb., as a conveying fluid means, using 2,200 cu. ft. of gas per minute. They reuse all dust made on three furnaces into one furnace, amounting to 70 tons per day. The regularity of the furnace is good and the result not discernible at the tuyeres, as far as sloppy conditions or burning of tuyeres is concerned. The same system is used at one other plant, where over 100 tons per day is injected into a single furnace.

Equipment for Handling Stock

At one plant are three furnaces with Neeland tub filling, as modified after its adoption in the Ruhr district. The material modification is in the use of a tub much larger than those with which you are familiar here such as Youngstown, Canton, Duquesne and Sparrows Point. There are also two other furnaces with double skip and McKee top. The furnaces differ in lines and capacity, but not materially, and are of typical German construction. The skip-filled furnaces make 7 per cent dust, and the tub-filled furnaces 3 per cent dust. Skip-filled furnaces burn but three-fourths as many tuyeres as do the tub-filled furnaces. The skip-filled furnaces make about 20 tons more per day a piece, and use about 40 lb. less coke. The pressure is said to be a bit higher on the skip-filled furnace, but both are under 16 lb. There is a trend toward skip-filling abroad. I believe they think that the greater flexibility of charging is worthwhile.

The bin system is distinctly different from ours. A typical layout would consist of a three or four furnace plant having concrete bins with a capacity of 100,000 tons ore and limestone in bins. There would be four or five scale car tracks running through, parallel with center line of furnace plant. Each track has one or two scale cars with two tubs into which the ore is weighed. Directly back of each hoist is a crane spanning these four scale car tracks, the crane bringing the tub to the base of the hoist. Coke is brought from the ovens in the tubs. Inclusive of scale cars, crane and hoist, three to four men are required per turn to charge the furnace.

Design of Furnace

Furnace construction is an inversion of ours, i.e., a brick stack with steel bands with cooling plates set in, and a steel plate bosh and tuyere jacket without plates, water cooled on the exterior. The whole structure is supported on heavy structural framework extending to the top platform.

As to lines, their bells are usually smaller. Linings are 0.9 meters (35½ in.) thick in the inwall. They have our conventional type of stockline protection on the top where they do not resort to metal tops. Inwall cooling is carried right up to the stockline wearing plates. As a rule they use a cast iron box on 3 ft. vertical centers, the plate having a 7 in. depth on the face and 9 in. horizontal spacing between plates. The end is open and the water under no pressure. The plate is about 20 in. in from the face of lining. Tremendous quantities of water are used on the bosh, tuyere and hearth jacket. Inwall batters are less than ours on the newer furnaces.

Boshes are higher than here, and do not usually go over 78 to 80 deg. angle, though one finds as high as 84 deg. However, the same hearth and bosh diameter seems to hold. It is as if one ran a 10 ft. 80 deg. bosh up to a 13 ft. 84 deg. bosh, the hearth and bosh diameter remaining say 20 ft. 6 in. and 24 ft. in each case.

Furnace sizes vary. Perhaps the best relative tonnage figure was a maintained average tonnage of 915 tons on a furnace of 16 ft. 5 in. hearth, 22 ft. 6 in. bosh, 14 ft. 9 in. high, 17 ft. stockline, having a height of 84 ft. and a cubic capacity of 22,300 cu. ft. This was on Swedish, Minnette and German ores, using eight large tuyeres and 1325 deg. of heat. Of the plants and operating furnaces seen, I would credit

ten with a better than 800 ton production rate. The remainder would average under 600 tons.

Speaking now of high tonnage furnaces, some remarkable rates are being maintained. For instance, one plant makes 930 tons per day on a 22,300 cu. ft. furnace. This is done without outside scrap on a yield of 54 per cent. The same size stack in 1914 made 550 tons. The wind volume is 120,000 cu. ft. per hour, blown at 14 lb. pressure through 8 tuyeres. A blast temperature of 1300 deg. F. is carried. Over a million tons had been produced on the lining, with an expectation of 1,500,000 tons. The coke rate was 2,080 lb. Low silicon Thomas iron ore is produced.

One can find creditable records of coke consumption, and at one plant a low rate of 1,750 lb. day in and day out, but it seems their coke rate is distinctly higher; for basic iron, I would say, easily 20 lb. per ton higher than ours. Three factors probably contribute: very intensive cooling of furnace walls, a somewhat coarse ore and limestone mix, together with refractory ores, and a rather inflexible charging system; add to this a fast-driving rate, up to 78 lb. coke per cu. ft. furnace capacity.

Hot Blast Stoves

Two-stove operation is common, but with three stoves to a furnace, one standing by hot and used perhaps every third or fourth round, or not at all, a bit of gas being burned occasionally to keep it hot. As long as there are three stoves one may as well use all three, and resort to two when one has to do so. There are many kinds of checkers but they divide into three classes. The Stumm checkers have been used, but don't seem to be in favor any more. Second, there are the single or double tiletype or octagonal type checker, having a $2\frac{3}{4}$ to $3\frac{1}{2}$ in. opening and $1\frac{1}{4}$ in. walls. The third type is the Kuhn and the Strack checker, the latter being used at the majority of new and remodeled jobs. Both are based on using a heavy 3 in. wall brick in the top, and a $5\frac{1}{4}$ in. opening. This extends for say 12 ft. Then the same size brick will have 4 to 7 holes and thinner walls. This for 4 ft. to 12 ft. Finally, the bottom 60 ft. or so of checker has from 7 to even 19 holes in the same size brick. Kuhn checkers are made square and Strack hexagonal. For practical purposes gas engine quality gas must be used on all of them, considering plugging or impregnation and fusion. Their efficiency is good, actually 80 per cent with three stoves in operation, and their heat capacity is quite as much in line. Pressure combustion has to be used. I append a comparison between typical American and German stoves:

	American	German
Size stoves	23 x 105 ft.	23 x 108 ft.
Size checkers	$4\frac{1}{2}$ x $2\frac{1}{2}$ in.	$5\frac{1}{2}$ to $1\frac{1}{2}$ x 3 to 0.82 in.
Heating surface	91,400 sq. ft.	162,000 sq. ft.
Weight checker brick ..	1,570,000 lb.	1,100,000 lb.

Due to the better utilization of all brickwork in checkers, the temperature drop in blast is the same as in the American stove, with its greater weight of brickwork.

Gas Engines

The largest gas engine I was able to get a quotation on was a tandem, blowing 51,000 cu. ft. at 22 lb. pressure and 65,000 cu. ft. at 15 lb. pressure. This engine had a cylinder bore of 4 ft. 9 in. air, tub bore

of 9.5 ft. and stroke of 4 ft. 9 in. The blowing tub could be increased to 10.5 ft. but at the expense of the pressure characteristic. The speed was 87 rpm. It is interesting that the heat consumption corresponded to but 7,200 cu. ft. of gas per min., whereas the best turbo blower-boiler combination consumes 11,500 cu. ft. Abroad, with the lower installation costs, the surplus gas figure swings the scale. A complete gas engine generator job, with waste heat boiler, building, gas cleaning means, and mains, can be put in for \$85 per kw., whereas here it costs at least \$160 per obtained kw. Another factor in their use is the prevailing application of d.c. for mill uses. Another factor is the fact that the mill load there is smoother, not so many or so extreme 15 minute peaks, so that it is not by any means uncommon to see a gas engine plant operating at an 80 per cent or 82 per cent load factor, and the engine waste heat boilers, giving about 0.1 kw. per 1 kw. secured from the gas engine, acting as steam accumulators taking the peaks, say 12 per cent in excess of average load.

Gas Utilization

This brings me to a final phase of German blast furnace practice, which is gas cleaning and gas utilization. There is a decided distaste for wet washing. Part is due to recent stringent regulations in regard to dumping dirty water back into the rivers. Part is due to the expense of wet washing, both in power and in heat value. I find much interest in Siemens-Schukert, in Elga and in Metallbank units—all essentially Cottrell but with modifications in size of tubes or plates and gas velocity and regulating means. The Elga type being the largest operation, I made a study of it at Witkowitz. Briefly, it cleans a 2.5 grain gas down to a 0.008 grain gas, delivering the gas at a temperature of between 175 deg. F. and 240 deg. F. at an expense 40 per cent of that of wet washing to a similar degree of fineness. The installation costs are 15 per cent higher. Power consumption is 50 kw. for 90,000 cu. ft. per min.

One plant produces 150,000 tons of steel a month, one-third open hearth and two-thirds basic Bessemer, from 120,000 tons pig iron. There are 260 coke ovens, and blast furnace gas is used on 100, giving a surplus of 28,000,000 cu. ft. per day, of which 80 to 88 per cent is used on the plant and the remainder sold. Of blast furnace gas above stove requirements, 55 per cent is used on gas engines, 36 per cent for heating, and 9 per cent is lost. There are about 175,000,000 cu. ft. used per day for heating, in conjunction with 22,500,000 cu. ft. of coke gas. An average Btu. of 140 per cu. ft. It is used in this ratio on reheating furnaces, being automatically controlled and burned both with and without generators, and heats $2\frac{1}{2}$ in. to 7 in. billets on a fuel consumption of from 4 per cent to 6.5 per cent coal equivalent. At soaking pits, blast furnace gas is used straight on modified regenerative pits, provided with smaller checkers and exhaust fans. They save one-third in fuel consumption over producer gas and run on a 4 per cent coal fuel equivalent. At the open hearth the mixture is left to the melter's judgment, except that a continuous sample is recorded. They use a 180 Btu. gas, varying from 240 at the start to 125 at the finish. They have to use 12 in. gas pressure to get results; an iron with over 0.6-0.7 per cent silicon gives trouble with stiff slag so tar is used in such cases. Use small check-

(Continued on page 497)

General Electric Erects Welded Building*

A Particular Interest Attached to the Use of Welding in the Construction of This Factory Building—Details of Workmanship and Tests Are Described

By FRANK P. McKIBBEN†

ALTHOUGH Building Number One, now being completed at the General Electric Company's West Philadelphia Works at Sixty-ninth Street and Elmwood Avenue, is first in number, it is not first in order of construction, as several other buildings have been in use for some time. This latest structure, differing from the others in that its steel frame is arc welded, consists of a head house or transept parallel with Elmwood Avenue, and two main aisles at right angles thereto. The headhouse is 78 ft. wide and 171 ft. long with vertical clearance of 43 ft. One aisle is 59 ft. wide and 474 ft. long with vertical clearance of 34 ft. from ground floor to lower chords of roof trusses, while the other aisle is 79 ft. wide and 474 ft. long with a reinforced concrete gallery floor, in all but the two westerly bays, nearly midway between the ground floor level and the lower chords of roof trusses. To be exact the gallery floor is 20 ft. above the ground floor, and is connected with a similar gallery in existing building Number Four by an enclosed passageway. These aisles and the headhouse comprise a building approximately 138 ft. wide by 552 ft. long with total ground area of 80,150 sq. ft. When completed the building will be used for the manufacture of arc welded steel tanks of various kinds and sizes.

Concrete spread footings in clayey soil serve as foundations for brick walls, steel columns and for the reinforced concrete columns supporting the gallery. The ground floor throughout consists of a wooden block surface on a concrete base on cinder fill, and the gallery floor is also wooden block on flat slab construction. Outside walls are of brick; and the roof gypsum slab cast in place. The building will be well provided with natural light from unusually large windows in all external walls, and from four lines of sawtooth skylights—two lines in each main aisle.

The steel frame consists of steel columns, made of new Carnegie beam types, between which are welded

transverse trusses of the Pratt type with parallel chords in the two main aisles, but with inclined top chords in the headhouse trusses. The latter trusses have spans C to C of columns of about 77 ft., and vary in depth from 8 ft. 4 in. at one end to 6 ft. 4 in. at the other to carry the sloping roof of the headhouse. One main aisle has roof trusses 7 ft. deep with 8 panels each 9 ft. 9 in. making the span 58 ft. 6 in. The other main aisle has 78 ft. trusses 7 ft. deep with 8 panels at 9 ft. 9 in. As all truss chords in the main aisle are horizontal and as the main purlins rest on the top chords of these trusses, roof slopes for drainage are provided for by sloping the secondary purlins.

In general each column had a 1½-in. cap plate welded directly to its web and flanges, but the 1½-in. base plate was in most cases not welded to the column. Each anchor bolt was connected to each column by passing between the column flange and a short angle standing vertically with outer edges of both legs welded to the face of column flange. The anchor bolt nut bears against a plate washer resting on upper end of the angle. The device is very simple. The bays in main aisle were 24 ft. to 25 ft. while those in the headhouse were from 25 ft. 7 in. to 29 ft. 3 in.

Roof Trusses

The design of roof trusses is characterized by the use of one 8-in. Carnegie beam for each top and bottom chord with flanges vertical; to the outer surfaces of which are welded channel diagonals and to inner surfaces 7-in. I beam verticals. By thus welding diagonals and verticals directly to chord flanges the use of over 1200 gusset plates were avoided in the trusses. Another feature is the absence of lattice bars, not only in all trusses but generally throughout the building. In only two members in the entire building were lattice bars used.

The fillet welds, of triangular cross section with base and altitude generally $\frac{3}{8}$ in. each, are subjected to the longitudinal shear, and the unit shearing stress used in the design is 3000 lbs. per linear inch for $\frac{3}{8}$ in. fillets. As the critical shearing section for a $\frac{3}{8}$ -in.

*Presented before the American Society of Civil Engineers in Philadelphia.

†Consulting engineer.

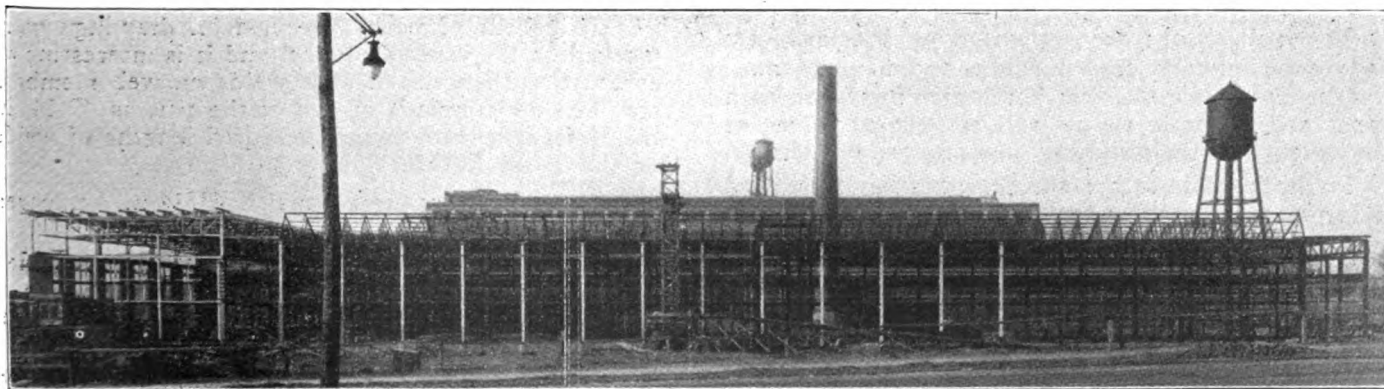


FIG. 1—General view of building.

x $\frac{3}{8}$ -in. triangular fillet is .265 in. this corresponds to a shear 11,300 lbs. per square inch. In comparison with many tests made by the General Electric Company this represents a factor of safety of at least four.

A roof load of 60 lbs. per square foot was used in the design, divided equally between live and dead, applied not only to the level portions of the roof but also to the sloping surfaces of skylight monitors. Unit stresses in steel members were those of the Philadelphia building code.

Horizontal bracing, consisting of diagonal rods with Carnegie beam struts, is provided in plane of truss lower chords in all bays of the headhouse and in the 58 ft. 6 in. main aisle where cranes operate, but in the 78 ft. main aisle with concrete gallery lower chord bracing is used only in four bays. And horizontal top chord bracing is provided in four bays of



FIG. 2—Interior view showing roof truss and crane runway.

both main aisles and in two headhouse bays. Vertical longitudinal bracings were also used in several bays to resist crane stresses.

Provisions are made for the following cranes:

In the headhouse 10-ton bridge cranes with span of 73 ft. 5½ in.; in the 59 ft. main aisle 10-ton bridge cranes with spans of 55 ft. and 2-ton wall cranes on either side; in one end of 79 ft. aisle one 5-ton bridge crane with span of 46 ft. 2 in. All bridge crane runway girders are Carnegie beams supported generally direct on top of auxiliary crane columns. The only exception is at intersection of headhouse and 59 ft. main aisle where the 10-ton headhouse crane girders are supported on a deep welded truss carrying not only the crane, but roof and clerestory loads as well.

The wall cranes are supported on brackets carried by the auxiliary crane columns and main columns. And as these cranes exert horizontal forces at both upper and lower levels as well as vertical forces at the lower level their runway supports are not simple.

In the headhouse are three interesting structural features; first, supporting one transverse headhouse 77-ft. truss on two longitudinal wall trusses at connection with this new building to an existing adjacent one; second, supporting one end of one transverse headhouse 77-ft. truss at the center of a 58 ft. 6 in. truss at intersection of headhouse and one main aisle; third, supporting headhouse crane runway girders by welding them to cantilever ends of two needle beams

supported by 58 ft. 6 in. trusses at intersection of headhouse and main aisle.

Welding

The use of welding resulted in a considerable saving of steel in a reduction of cost of the steel frame, in the elimination of noise due to riveting, and in promoting the electrical industry. Having a total of 989 tons of steel of which 745 tons passed through the welding shop of the American Bridge Company at Trenton, N. J., this building is one of the heaviest among welded structures. It is also unique in that it exceeds all other welded buildings in the use of trusses.

At the Trenton fabricating shop generally five welders were used each using a single operator motor generator set which consists of a generator, control panel, motor, starter and reactor assembled on a base. At the building site in West Philadelphia two welders were used each supplied with a machine brought from Trenton and made portable by mounting on simple hand trucks.

When depositing a $\frac{3}{8}$ -in. x $\frac{3}{8}$ -in. triangular fillet the arc voltage was about 23 to 25 and amperes 175 for 3/16 in. General Electric welding electrode type F. D.c. was used and was subject to control by the operator, the current being changed by shifting the brushes, low voltage for light work and higher voltages for heavy work.

In the fabricating shop a series of 18-in. I beams from 21 ft. to 24 ft. long were supported about 9 ft. apart on the shop floor, and connected together with a steel bar welded to each beam. The positive terminal was bolted to the web of one of these beams, and the negative connected to the 3/16-in. x 24-in. electrode in the electrode holder held in operator's hand.

The 206 skylight trusses were nearly alike and were assembled by clamping the members in jigs which expedited the process greatly. Jigs for small triangular trusses can be made by welding flat plates to skids, then welding small angle clips to the plates so that when the truss members are laid against the clips the truss is quickly assembled and clamped then either welded in place or removed for welding.

The large trusses were put together by first laying the bottom chord against a long 8-in. x 8-in. angle welded to the I beam skids, then the top chord spaced and clamped to skids, finally verticals and diagonals were clamped to the chords, and the joints welded. All trusses were assembled and welded lying flat on the skids.

All lengths of welds specified on drawings were marked on the assembled steel and it is interesting to compare the lengths of fillet welds on web members specified on drawings of one of the trusses, T 14, in the 78 ft. aisle with actual measured lengths of welds on the truss. Results follow:

1—Total length of actual is 633¼ in. compared with 598 specified.

2—Maximum excesses of actual over specified for any one member is 5½ in. or 46 per cent of specified weld; and 6¼ in. or 52 per cent for another fillet.

3—Maximum deficits of actual as compared with specified for any one member is 1½ in. or

6 per cent of specified weld; and $3\frac{1}{2}$ in. or 8.8 per cent.

4—Individual fillets may be as much as 10 per cent shorter than specified.

All of which shows inspection necessary, but that maximum deficits are not sufficient to appreciably reduce the factor of safety. It is probably that in-truss work costs can be materially reduced by use of jigs for rapid assembling of truss members, and by specifying on the drawings actual rather than imaginary working points.

The shop fabrication and field erection required nearly two months each for this West Philadelphia building Number One.

Tests

The design of this building was based in part upon tests made by Rensselaer Polytechnic Institute for the General Electric Company. The plates were of such sizes and thicknesses that at the ultimate loads the stresses in the plates were much below the elastic limit. For specimens in tension the $\frac{3}{8}$ -in. x $\frac{3}{8}$ -in. triangular fillets of varying lengths gave an average longitudinal shearing strength of 13,300 lbs. per linear inch of fillet. Whereas, compression specimens with varying lengths of $\frac{3}{8}$ -in. x $\frac{3}{8}$ -in. fillets gave from 17,800 to 15,800 lbs. ultimate shearing strength per linear inch of fillet. It is apparent that the 3000 lbs. per linear inch used in design for this building gives ample security.

At Trenton three 58 ft. 6 in. trusses were temporarily erected for testing, being supported and braced and erected in the same relative positions that they were to occupy finally in the completed structure. Test loads consisting of I beams were then applied to the top chord joints through purlins until the center truss carried a total load equivalent to $1\frac{1}{2}$ times the load for which it was designed. As the total design dead load was 30 lbs. per horizontal square foot and the live the same amount this test load was equivalent to the full dead plus twice the live load.

The vertical deflection at center top chord joint checked very closely with the calculated deflection. Deflections were observed till the truss was carrying the design load when the central deflection was .52 of an inch, then continued till the truss supported the design dead load plus double the design live load at which time the deflection reached .78 of an inch. As the loads were removed the deflections decrements were almost exactly equal to the increments under increasing loads. Till finally upon removal of all applied loads the truss occupied exactly its initial position showing that no slipping in joints took place under the test.

Before any welder was allowed to do work on this building either at the fabricating shop or the building site, he was given certain tests by a capable welding inspector and his work was subsequently watched by the inspector. A comparison in accomplishment was secured at Trenton by having each of the five welders make two test pieces consisting of two 6-in. x $\frac{7}{8}$ -in. main plates spliced by two 5-in. x $\frac{1}{2}$ -in. plates with 10 in. of $\frac{3}{8}$ -in. x $\frac{3}{8}$ -in. fillets on each side of the splice. These 10 specimens were then tested and showed that, while the two specimens made by any individual welder showed remarkably close results, the variation between the lowest average and the highest, i.e., be-

tween the poorest and best welder, was about 22 per cent of the lowest. The lowest values, however, were practically the same as those used in design. It is the lowest value that controls, not the average. Of course, two specimens per welder are not many, but taken in connection with other tests and accomplishments of these five shop welders it is believed that the specimens represent shop variations. These are no greater than exist in concrete tests or in riveted joint tests.

Blast Furnace Operation Abroad

(Continued from page 494)

ers and forced air and gas with exhaust fans, and have a stack temperature of 875 deg. F. and have discontinued the waste heat boiler. Fuel consumption is 14 per cent coal equivalent. There are a number of problems to be anticipated and provided against to make all this possible, but they have cut out all solid coal uses except in transportation. The coal saved is 800 lb. per ton steel. It is obvious this would be impossible with 100 per cent open hearth operation.

Speaking of European plants in general as against American, perhaps our plants do not have the elaborations and refinements that one finds abroad. But they are simpler, and less expensive to build, even though more sturdy in the furnace itself. A comparison of weight is given, both typical, I believe:

	American	German
	Cu. ft.	Cu. ft.
Cubical contents	20,000	21,200
Weights:	Lb.	Lb.
Furnace	1,340,000	2,012,000
Skip	260,000	1,580,000
Bins	950,000	5,000,000
Stoves	900,000	800,000
Gas cleaning	250,000	700,000
	3,700,000	10,092,000

The bins being used as ore storage, we should add the equivalent of an ore yard and bridge, but not including car dumper, as both are hand unloading propositions. This would add about an equivalent 2,300,000 lb. to the American weight, giving 6,000,000 lb. versus 10,100,000 lb.

As to operating costs, if we put raw materials on a parity, labor and supplies on a parity, the cost of a ton of pig iron is approximately \$2.10 higher for a Ruhr type plant than at a modern American plant, using the same materials and labor and material costs.

As to construction cost, the typical Ruhr district plant with its bins, heavy hoist and furnace, elaborate gas cleaning and gas engines, will cost approximately \$26 per ton per year, as against \$20 per ton per year here.

As to labor, taking a single furnace plant, they will run 5 tons per man per day, as against our 6 tons per man per day. I am taking modern outfits in both cases and avoiding extremes, though using a 900-ton German base.

Furnace practice itself is, if anything, easier on men and supervision force there, due to physically better average coke and ore and a higher proportion of beneficiated fines and low grade iron-bearing materials.

Steel Plant Engineers Hold Meeting

Members of Two Engineering Societies Hold One-Day Conference on the Rolling of Strips and Sheets on 4-High Mills, Roller Bearings for Mills, and Normalizing Furnaces

By CHARLES LONGENECKER

AT a joint conference of the Mechanical Section of the Engineers' Society of Western Pennsylvania and the Pittsburgh Section of the American Society of Mechanical Engineers, on April 3, three papers of exceptional interest to steel mill engineers were presented.

The first paper, by F. C. Biggert, Jr., president of the United Engineering & Foundry Company, dealt with 4-High Mills and the Development of Their Rolling Practice; the second, by Fred Waldorf of the Timken Roller Bearing Company, was a recital of the Development and Application of Timken Tapered Roller Bearings for Steel Mill Equipment, and the third, by C. P. Mills, chief engineer of the Duraloy Company, described The Construction and Operation of Kathner Normalizing Furnaces. Two of these papers were read at the morning, and one at the afternoon session; both presided over by Mr. G. E. Dignan.

Due to the fact that these papers were of a decidedly practical nature, and covered the various operating features in a thorough manner they drew forth considerable discussion.

Among those who took part in the discussion were Barton R. Shover, G. E. Stoltz, W. W. Macfarren, I. W. Frank, A. T. Kathner, W. B. Skinkle, L. B. McMillan, G. P. Hansen, and C. E. Bigelow.

Papers of Messrs. Biggert and Mills, abstracted, follow; that by Mr. Waldorf will appear in a later issue.

Four-High Mills and the Development of Their Rolling Practice

By F. C. Biggert, Jr.

So much has been written of four-high mills within the last few months, that it is rather difficult to present any new material on the subject, and it is accordingly proposed to devote this paper mostly to the rolling practice which has developed from operation to date.

The object of the design is to provide an exceedingly inflexible working roll of relatively small diameter. This was, to some extent, accomplished many years ago by Lauth who used a large top and bottom roll with a small middle roll in his three-high plate mill. At a later date four-high mills were installed for armor plate at Homestead, and still later (1916), the same principle was used in the 206-in. plate mill at Lukens Steel Company. As opposed to Lauth's three-high mill, the four-high has the advantage that both working rolls are of small diameter, and consequently the pressure necessary to produce a given reduction, is less in the four-high mill.

Other types of backed-up mills, having this same advantage, have been proposed and used, but of these the only one of importance at present is the six-roll or cluster mill in which each working roll is supported

by two backing rolls. A number of these mills have recently been built for cold rolling.

We have adhered to the four-high type for two principal reasons which, we think, are sufficient to recommend it:

1—It is more simple and accessible. This will be clearly seen upon the most casual comparison.

2—Its arrangement removes all limitations as to roll, neck and bearing dimensions.

Some explanation of this statement will be necessary. In the cluster mill the two backing rolls applied to each working roll must be placed as close together as possible, practically in contact, and in practice must not be more than about twice the diameter of the working roll. If these conditions are not maintained, the working roll is so completely surrounded by the backing rolls that insufficient operating space remains. In the four-high design there is no limiting condition, and any suitable ratio of roll diameters may be used.

Pressures on the Backing Rolls

The fact that two rolls are used in the cluster mill where only one is possible in the four-high type, naturally reduces the size of the backing roll necessary to produce a given stiffness, but this effect is not so great as at first appears. The flexure of a roll varies inversely as the fourth power of its diameter, in consequence of which the single roll of a four-high mill need have only 19 per cent larger diameter than the two rolls of the cluster mill, to give equal stiffness.

But the possibility of unlimited stiffness of the backing roll is not the most important advantage of the four-high type. It is the freedom to use necks and bearings of unlimited sizes that most strongly recommends the design. This, of course, has reference to the use of roller bearings which are assumed to be used. In order to provide ample safety factor, these bearings assume large dimensions, and since the beginning of our work, we have found it advisable to continually step up in bearing size and capacity, and doubtless as the possibilities of the mills develop, still further increases will be found necessary. The bearings we have used are doing the work so far required of them, but the probability is that greater demands will be made, and even under present demand, we do not yet know whether a sufficient average life will be obtained. In the four-high mill, the bearing sizes are practically unlimited, whereas in the cluster mill, there are quite definite structural limitations. Here again we must allow for the use of two bearings in cluster mills to take the place of one in the four-high, but the angular forces produced by the cluster arrangement partially nullify this advantage and require that each bearing of the cluster mill shall sustain about 70 per cent of the load imposed upon the single bearing of the four-high mill under identical working conditions.

The Advent of Roller Bearings

The importance of the preceding discussion relating to mill types will be more evident when we consider the advantages of roller bearings on mills for rolling wide thin material. It is the development of a mill arrangement in which the dimensions of roller bearings, having ample load carrying capacity, determine the roll diameters as opposed to an arrangement in which roll sizes determine bearing sizes, which constitutes the real advance in rolling practice.

As previously stated, the use of four-high and other types of backed-up mills is old, but prior to the application of roller bearings, the accomplishments of these mills were only slightly better than those of ordinary two and three-high mills.

It must be born in mind that all mill neck bearings and particularly those on plate and strip mills, operate under conditions very near the seizing point. Wear and heating in such bearings are many times more severe than in machine bearings where ample size and thorough lubrication are possible. It should further be remembered that wear and heating increase rapidly with speed, and that both accuracy of rolling and continuity of operation are intimately related to these factors.

It is doubtless true that by running slowly enough a four-high cold mill with ordinary bearings might be built to roll strips such as are now rolled in roller bearing mills, but even with slow operation, the utmost care would be necessary to obtain accuracy of gauge, and the tonnage output would be relatively small.

When we consider hot rolling, there appears no possibility of commercial operation on wide widths without roller bearings. We cannot slow down since the material would become too cold, and at high speed, no amount of skill could maintain even an approach to commercial accuracy of product.

The roller bearing is thus the crux of the situation. It operates substantially without heat or wear and is particularly adapted to high speed. The only difficulty is that its dimensions precluded its use in ordinary two or three-high mills except under comparatively light rolling loads. This difficulty has been removed by using four-high mills where roll diameters may be selected without regard to any factor except the space requirements of the roller bearing. It was the perfection of this combination that started the recent and remarkable change from the long established practice for producing wide thin metal products.

Power Saving by Roller Bearings

You may be surprised that no mention has been made of the power economy of roller bearings, but doubtless you now perceive that however important this is, it is secondary to other considerations. Without the roller bearing, the operation is not commercially possible regardless of power requirements. The power saving is really a by-product, although fortunately a very valuable one.

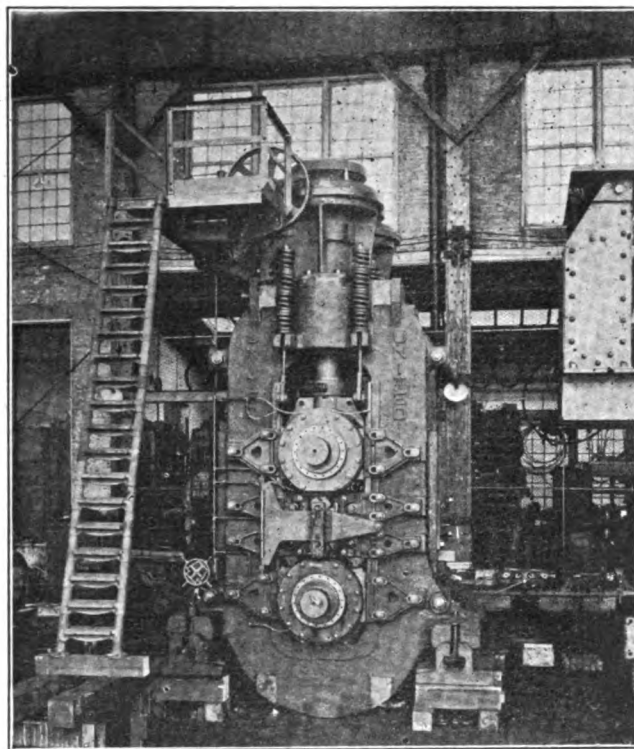
In a cold mill and at the finishing end of a hot mill where the power requirement is greatest, the saving, due to the four-high roller bearing mill, is approximately 50 per cent, that is, equal tonnages of like sizes, rolled from like slabs, require about one-half the power in a four-high roller bearing mill as would be required in a two-high mill on ordinary

bearings. At the roughing end of a hot mill, where the metal is thick, this ratio probably does not apply, but the saving in power is substantial there also.

Mills of this type have now been operating for a sufficient time to develop at least the beginning of a mill practice, and it will, perhaps, be of interest to discuss some of these developments. Engineers will be coming more and more into contact with the new mills, and it will be useful to the industry, as a whole, to have them cognizant of some of the fundamental requirements.

Accuracy and Skill Required

First, let it be said that these mills cannot be run with a monkey wrench and a sledge hammer. They are highly refined machines capable of great accomplishments under proper care, and equally capable of punishing the thoughtless and unmechanical operator. The crowbar mechanic has no place on the crew of a modern strip mill, and the sooner mill operators realize this, the better for them and their companies. One roller bearing on a large mill may cost as much as \$4000, and an improper adjustment or careless assembly may utterly ruin it in one minute. Some of the mills will produce more than a ton of steel per minute, and improperly ground rolls or faulty guide setting, may cobble 10 or more tons in as many minutes to say nothing of lost production. Evidently we have here no plaything for a child.



A 48-in. four-high hot strip mill showing roller bearing mountings.

In rolling thin material, we are dealing in measurements of a few thousandths of an inch, and every part of the equipment must be made and assembled with corresponding accuracy. In rolling 18 gauge strip, .001 in. is 2 per cent of the thickness, and an error of 2 per cent is, under some conditions, sufficient to make the difference between failure and success. Failure to comprehend this nicety of adjustment has

already caused some grief, and doubtless it will cause more.

Holding Long Strip in the Mill

Proper distribution of metal at an early stage in the rolling is of the utmost importance. All strips are rolled with a slight fullness in the center. This is necessary to guide the strip properly in the mill, as a perfectly flat strip, or one thick at the edges, is in unstable equilibrium while rolling and will run to one side or the other of the rolls. It is quite surprising how little this central fullness need be and yet how absolutely essential. A strip 36 in. wide x 16 gauge may be successfully rolled if it is .002 in. full in the center, but cannot be rolled if it is dead flat. This applies to long strips. Short sheets may be rolled dead flat provided there is enough free roll space to prevent their running into the necks, but the real economy of the mills is realized only on long material.

But if you would have .002 in. fullness at 16 gauge, you must provide the metal for this fullness while the metal is thick. Two-thousandths of an inch is roughly 3 per cent of the thickness of 16 gauge stock, but to get it and have a flat strip, you must provide 3 per cent excess metal at the center when the strip is not less than $\frac{1}{2}$ -in. thick. Indeed, it is much better to start at the first pass and continue throughout with an excess of 3 per cent at the center. By so doing, the final piece will have reasonably square ends, will not be buckled and will have a better surface.

Proper Contour of the Rolls

To get .002 in. fullness in the finished product, does not mean that the rolls are concaved .002 in. On the contrary, they may even be a few thousandths full. There is some spring and some deformation of rolls even in the stiffest mill, and it is a matter of careful judgment and experience to determine the proper contour of roll. Furthermore, the backing rolls wear, and since they are not changed except at infrequent intervals, the working rolls must be ground to correspond to the worn condition of the backing roll. In this respect, the practice in shaping the rolls, corresponds roughly to plate mill practice where successive middle rolls are increasingly crowned until the time comes to change the top and bottom rolls. The difference in strip mills is that the requirements are much more exacting. Turned rolls cannot be used, and the best grinders and most accurate micrometers are none too good to insure satisfactory results.

Backing rolls do not need changing so frequently as working rolls, but it is easy to be deceived by appearances and thus allow the backing rolls to remain too long in the mill. It may be surprising to some that even though the backing roll may be several thousandths out of round, the mill may still roll commercially accurate material. This applies to both hot and cold mills and is due to the relatively large spring of the mill as compared to the error in roll dimensions. Some very heavy cast steel housings which we have tested to full calculated rolling pressure, have elongated as much as .030 in., and when we allow for compression of screw, deformation of rolls and so on, the total spring of the mill will probably amount to .050 in. A mill so loaded may be reducing as little as .002 in. and frequently about .010 in. Now an eccentricity of .004 in. in the rolls with a mill having .050 in. spring and reducing .010 in. will vary the rolling pressure

from maximum to minimum, and consequently to amount of reduction, by only 2 per cent or less than .001 in. which, in roughing operations and even for some finished material, is sufficiently accurate.

Program for Changing Rolls

Of course, the object in discussing the possibility of rolling with inaccurately shaped rolls, is not to recommend the practice. On the contrary, it is to show that the fact that the mill is producing acceptable product is not proof that the rolls are in perfect condition, and to lead up to the importance of a definite routine of roll changing.

When backing rolls are left too long in the mill, concentrated bearings develop to such an extent that serious damage is done to backing rolls, working rolls or both. Roll breakage is increased but spalling is usually the first indication of trouble.

In some of the hot mills now working, a practice of changing backing rolls every fourth week, has been adopted, but as larger productions are obtained, it is likely that more frequent changes will be found economical, especially on the last three or four stands. For each mill a proper interval may be determined from practice, and it is preferable to make somewhat too frequent changes. This is a matter of great importance to successful operations.

Another highly important point is the exact equalization of working roll diameters. On both hot and cold mills, the rolls in each stand should be matched as closely as good micrometer callipers will permit. On a 16 in. diameter roll, the error should not be over .002 in., and roll turners accustomed to ordinary mill practice usually have a new art to learn when this degree of accuracy is required.

Accurate matching of rolls gives two important results. It is obvious that with rolls of different diameters in the same mill, there must be slippage either between the rolls and the metal, or within the metal itself, and neither of these conditions is conducive to good product.

Slippage Due to Unmatched Rolls

I believe that when the differences of diameter of rolls is around .004 in. or .005 in., as is likely with ordinary spring calliper measurements, the slippage usually occurs within the metal even in cold rolling, and in hot rolling this condition must obtain even with much greater differences of diameter. This opinion is based on the observation that where improperly matched rolls are used in hot rolling, there are no markings on the metal which may be attributed to roll slippage. It seems almost certain that if the roll slipped on the piece, the action would go by jumps. Once started slipping, the roll would run ahead and then slow up until the slipping force had again accumulated. All frictional slippage has this characteristic due to the higher coefficient of stationary friction.

In cold rolling where the metal has a very high resistance to internal slippage, and where oil is used on the rolls, there may be slipping between roll and metal, and it is likely that the faint cross lines on the product, commonly known as "pinion marks," are sometimes due to this cause.

In any case, it is certain that in thin rolling, whether hot or cold, all slippage must have a detrimental effect upon the metal and should be reduced to the lowest practical minimum.

The other important reason for accurate matching of rolls, relates to the mechanical operation of the mill.

Effect of Unequal Roll Diameters on Mill

The mill pinions are of equal diameter, and for every revolution they make, the rolls must also make one revolution. But in rolling thin material, particularly cold material, the rolls are so strongly pressed against the material that they may be considered as almost equivalent to another pair of gears on the same shafts as the pinions. Now supposing the rolls to have unequal diameters, it is obvious that strains will be set up within the machine which may become very great.

If there were no slip and the rolls were different in diameter by 1 per cent, the torsion in spindles and the pinion tooth pressures would theoretically be ten times those due to the torque applied to the mill. Practically these stresses could not reach this maximum since either breakage as slipping of rolls would relieve them. The point is that, with unequal rolls, both the torque in spindles, and the pinion tooth pressures, may reach several times the torque applied by the motor. This does not imply that the mill acts as a perpetual motion device. It is multiplied stress, not power that is involved. The effect is roughly comparable to that of the wattless current of an electric system operating under a poor power factor. This somewhat theoretical discussion is included to show the great importance of well-matched rolls, but no theory is necessary to demonstrate the effect of improper matching. The clashing of spindles and wear of pinion teeth, will promptly announce the overloads to which they are subject when improperly matched rolls are used.

Function of Guides

The arrangement and adjustment of guides is of importance mainly to insure that the path or bearing of successive pieces be on the same part of the roll, and that the line of entry be perpendicular to the rolls. In other words, the control of the metal, after it enters the mill, is obtained almost entirely independent of the guides.

This will be obvious when we consider the very small contact area of the guides compared to the width of the strip. There can be very little guiding effect from the pressure of a guide bearing upon the edge of a strip say 30 in. wide and only 1/16 in. thick. The lateral control of the piece must, therefore, be accomplished almost entirely by careful adjustment and shaping of rolls.

Suppose that in a mill with all rolls ground parallel, we enter a strip of annealed steel 30 in. wide, .100 in. thick at edges, .103 in. thick at center, and make a reduction of only 5 per cent. The delivered strip will have almost no fullness at center, but will be badly buckled and useless because more reduction has been made at the center than at the edges. If we now enter a similar strip without any change except bringing the rolls together enough to produce a 10 per cent reduction, the delivered strip will be much less buckled and will have more fullness at center. The added pressure has changed the working shape of the rolls so as to more nearly conform to the shape of the entering piece. If we repeat the operation with say 15 per cent reduction, the strip may come out without buckles, and having been reduced by exactly the same percentage at edges and center. This action is very important to the mill operator. Without it, he would be compelled to grind his rolls differently for almost every change in

width or gauge of product; by its use he is enabled to shape his mill to a wide range of requirements by the simple expedient of varying his reductions.

Now refer back to our supposed operation, and we find that when suitable adjustment has been made, we are entering material .100 in. thick at the edge and .103 in. at center, and delivering .085 in. at edges and .0875 in. at center. The rolls which were ground exactly straight, are curved under working conditions, so that they produce exactly 15 per cent reduction at every point on the full centered strip which we are rolling.

Now suppose that the strip begins to travel across the face of the roll say toward the right. The reductions at various points across its width immediately change. The righthand edge coming nearer to the end of the roll, receives an increased reduction, and the lefthand edge moving toward the center of the roll face, receives a less reduction.

But it is common knowledge that any flat material between rolls will move toward that end of the roll which is producing the least reduction. Then obviously movement to the right cannot continue. The strip will settle into a stable position in the middle of the roll face, and slight variations which must occur in thickness of entering strip, can cause it to wander only momentarily from its path.

This is the reason for rolling with a small amount of fullness in the center. It also explains the previous statement that the guides are mainly of importance in entering the strip, and cannot be depended upon thereafter.

Control of Roll Shape by Heat

In cold rolling and, to some extent, in hot rolling, we have still another means of controlling roll shape by the local application of heat. If a mill becomes hollow and has insufficient crown, several thousandths of an inch may be added to its diameter at the hollow point, by a properly directed gas flame. This is most conveniently accomplished by heating the large backing roll. The heat, of course, gradually distributes itself in both directions from the point of application, and thus develops a very suitable bulging of the roll. To illustrate the possibilities of this method, it may be noted that an average increase in temperature of 50 deg. F. in a 40 in. diameter roll, will give an expansion of about .012 in., and with suitable burners, it is not difficult to maintain such a temperature difference, although it would be considered extreme.

In shaping rolls by heat, care is necessary to avoid damage to the rolls. The mill should always be in motion before burners are lighted, and the burners should produce a broad flame rather than a narrow concentrated one.

Some operators have applied heat directly to the working rolls, but we believe this unwise particularly when hardened steel rolls are used. It is preferable to heat only the top backing roll and to change the mill when the rolls have become so hollow that excessive heat is required to keep the mill in shape. More expansion could be had by heating both backing rolls, but this involves much greater skill in controlling the mill, and is not usually a satisfactory procedure.

These are some of the important points of operation which have so far developed in the operation of the mills, and this long discussion of them, may leave the impression that the difficulties involved are practically insurmountable, but actual results have shown that this is not the case.

Both hot and cold mills are running at high production rates, and where the crews are well broken in, no great difficulties are encountered. Once properly adjusted, the mills require comparatively little attention, and the economies possible, are sufficient to warrant all the skill and thought necessary to their proper operation.

Construction and Operation of Kathner Normalizing Furnaces

By C. P. Mills

The Kathner normalizing furnace is the result of many year's work on the part of Mr. Kathner. He endeavored to develop a furnace that would produce a sheet having deep drawing qualities, better than any others on the market at a cost below the general practice of the day. He early realized that a great deal of the heat was being lost by the water cooling of the shafts, and attempted to over-come this difficulty by means of an insulated disc. In this he was successful.

He then investigated the heat losses from the average normalizing furnace and, realizing that considerable loss took place throughout, developed a system whereby the bottom, side walls and roof were completely insulated. This immediately produced a better quality sheet.

Mr. Kathner, on becoming associated with the Weirton Steel Company, had the opportunity to install a 100-ft. furnace, incorporating all of his ideas. This was built, and verified all of his claims. His experience with normalizing furnaces early showed that he should develop a furnace that would not need to be

19, 1927, The Duraloy Company, in connection with the Rust Engineering Company, entered into contract with The Newton Steel Company to build two 155-ft. furnaces, one of which they agreed to have operating on January 15. This schedule was possible due to the experience and personnel of the Rust Engineering Company and the facilities at their command, combined with the ability and facilities of The Duraloy Company to produce, machine, polish and assemble over 65,000 lbs. of Duraloy parts. On January 12, the first furnace was lighted and on January 17 the fire was started in the second furnace.

General Plan of the Furnace

These furnaces divide themselves into two main sections; first the heating zone, 75 ft. long, and the cooling zone, 80 ft. long. The heating zone consists primarily of two parts: a preheating and a soaking zone. The first 35 ft. of the furnace might be called the preheating zone. In this section there are no burners in the first 15 ft. while the balance of this part of the furnace and what we call the soaking zone has burners the full length. By use of this preheating zone the loss of heat out of the end of the furnace is reduced to a minimum. The front part received its heat by the back flow of gases from the balance of the furnace. The heating zone is equipped with both oil and gas burners. This section of the furnace; that is, the preheating and soaking zones, is built up in two main parts consisting of a bottom section and a removable top. The bottom section is divided into sections of predetermined length to provide for expansion. In this manner the total expansion of the furnace is not cumulative and there is no creeping of the side walls which would cause binding on the shafts and would be very disastrous.

The two independent sets of burners are necessary so as to allow the use of oil at a time when natural gas is not available. For the oil burners it was decided to use inducing burners manufactured by the Smokeless Oil Burner Company of Bucyrus, Ohio, which operate with high pressure steam as the atomizing agent. The gas burners are of the self aspirating type and were furnished by the Needham Gas Appliance Company of Passaic, N. J. They use high pressure gas and aspirate their own air; consequently are very easily controlled with automatic equipment.

The cooling zone is in many respects similar to the heating zone. The same general type of construction; that is, an insulated bottom and the sectional type top is carried out, but the roof is lowered. The cooling zone required no heat storage as stored heat in this case would have a tendency to prevent the rapid cooling of the sheet which is necessary to give certain deep drawing qualities. The top sections in this part are made of structural steel and are insulated and brick lined. In this portion the sheet is cooled from its maximum temperature to a temperature low enough to allow piling without grain growth or to a temperature of about 900 deg. F.

Discs and Shafts

The conveying mechanism used throughout the furnace consists of Kathner type insulated shafts. There are 86 of these shafts made out of Duraloy and 40 of semi-steel. These shafts consist of seamless steel tubes on which are mounted Duraloy or semi-steel discs and spacers, and the space between the hub and the shaft is filled with a special insulating mixture, which

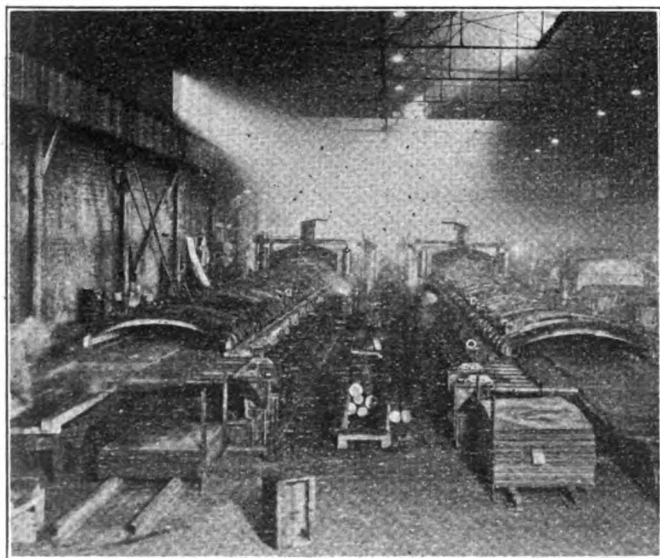


FIG. 1—General view, cooling zone.

shut down over weekends for repairs, and this lead him to develop a type of sectional construction which he incorporated in the Weirton furnace. Here he was able to observe the results over a period of a year and eliminate minor difficulties. It also gave him an opportunity to experiment with various materials, which resulted in his standardizing on certain equipment.

On the termination of his connection with The Weirton Steel Corporation, Mr. Kathner became connected with The Duraloy Company and on November

is found to be particularly suited for this work inasmuch as it does not have a tendency to pulverize and drop out. The discs and spacers are lined on the shaft by means of fingers which insure a uniform amount of insulation around the seamless tube. These discs are bored slightly larger than the diameter of the tube, thereby assuring, in addition to ease of assembly, that

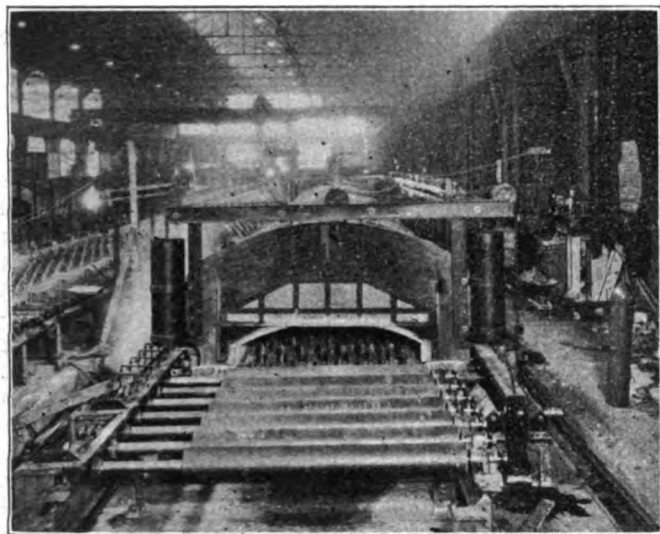


FIG. 2—View of ingoing end.

not more than one of the three points on each disc will come in contact with the tube. This tends to cut down conduction of heat from the rim to the tube and results in the discs being at practically furnace temperature. A solid hub disc were used. A great deal of loss of heat in the old type of normalizing furnace is, as I have stated before, through the shaft. In assembling the shafts before they are erected the total expansion is figured, and the discs spaced with sufficient clearance to provide for the maximum condition.

The driving collars are then keyed fast and the key welded in place so as to prevent any creep along the shaft which would tend to cause binding on the side wall. The discs and spacers are constructed with dog ears and match into each other and into the driving collars at the extreme ends, which are keyed to the shaft. One end of the shaft is plugged and the other end is connected with the water cooling system. This end also has a brass drip cup which prevents the water from traveling back along the tube to the bearings and from there to the floor, eliminating the common results found around most normalizing furnaces, of a sloppy condition on the floor. The discs are spaced on the shafts on 8 in. centers and the shafts on 15 in. centers. This arrangement of 15 in. center to center of shafts and 8 in. spacing on the shafts with a stagger was developed as being the most satisfactory to handle all types of sheets from the lightest gauge up. Shafts with Duraloy discs were used throughout the heating zone and for some distance into the cooling zone, and the balance of the furnace was equipped with semi-steel discs. Semi-steel was decided on as it gave better results than cast-iron—cast-iron having a tendency to grow and is not as resistant to heat.

Insulation Problems Solved

It might be advisable at this point to say a word or two more about the insulation. The insulation of

the shafts presented a problem due to the fact that the maximum temperatures encountered are at or near the limits of an uncalcined material.

Most plastic or powdered forms of insulating materials have a high percentage of shrinkage at these elevated temperatures. The question of using a powdered form was found impractical not only from the standpoint of excessive shrinkage, but due to the inability of preventing it from running out through the spaces between the discs that had to be allowed for expansion.

The addition of a binder to the powdered form did not prove sufficient to hold it in place and a search was made for some material that would overcome this difficulty. A fibrous form of material was tried and this, due to its fibrous condition, was more successful, but in order to secure further strength a semi-refractory binder was added, which, while it slightly reduced the insulating value of the fibrous material, it more than made up for this in the reduction of shrinkage and tendency to shift, which was completely eliminated.

For the lining of the top sections, walls and bottom a material was used having a high heat insulating value so that thin sections could be used in order that the construction might not become bulky. It was further desired to use a material that came in rather large slabs so as to increase the speed of erection. Here also shrinkage bears an important part, and for these reasons Super-Ex was used and has proved very satisfactory.

The sectional type of construction used in this furnace is of such a nature that all of the units of any section, that is, either the cooling or heating zone, are interchangeable with each other, except the two end sections in the heating zone. These two end sec-

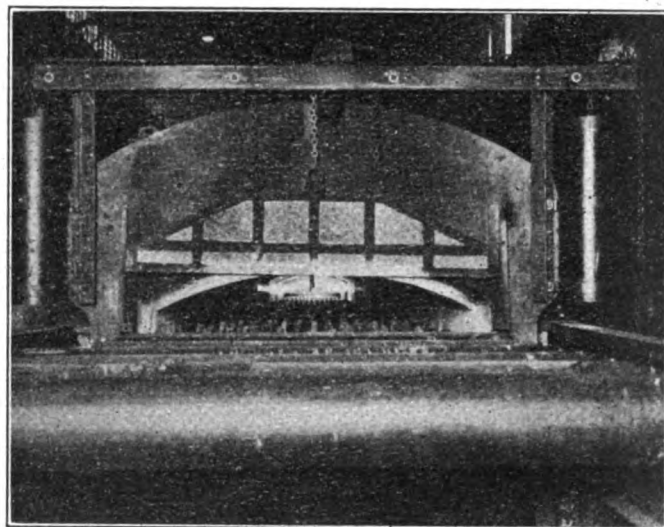


FIG. 3—Door. Note rectangular design to allow expansion.

tions have a taper and are provided with a stack opening, and that one which is assembled nearest to the cooling zone has a stack installed on it. This stack, however, is encased in a steel jacket and can be lifted off as a unit. Between the heating zone and the cooling zone is placed a Duraloy door. By means of this stack and the Duraloy door a perfect control of the temperature and atmosphere in the cooling zone can be maintained. If the cooling is taking place too quickly it is possible to close the damper on the stack,

open the door, and allow more products of combustion to escape through the cooling chamber, thereby maintaining a slightly higher temperature or a more reducing atmosphere. After the furnace is once in operation it is very seldom necessary to change this adjustment. It is, however, very easy to do and more than justifies its installation by the results obtained.

Temperature Control Equipment

One of the features of the successful operation of these continuous sheet normalizing furnaces is the automatic temperature control equipment supplied by the Brown Instrument Company. This equipment consists of two automatic temperature controllers per furnace, which are placed so as to control two definite heating zones to which the fuel is automatically regulated to give uniform annealing temperatures in the particular zone to which they are applied. Although at the present time these furnaces are fired by steam atomized oil and the automatic control mechanisms are functioning valves on the oil and steam lines, these control mechanisms are also provided with valves to be placed in high pressure gas lines in case it should be desirable or more economical to use natural gas at some later time.

For the special convenience of the furnace operators all of the controlling instruments and mechanisms are placed at a point central to the two furnaces. The operator can here observe the chart records of the four recording control instruments, and easily make changes from time to time of the actual temperatures at which he wishes to operate the furnaces, changing these temperatures according to the requirements of the sheets being annealed. The four control mechanisms with their valves are located near the control recorders so that the operator can make any valve adjustments necessary conveniently and quickly, and at the same time observe changes in furnace temperatures resulting from this valve adjustment.

In addition to the temperature control equipment, flow meters for metering the amount of steam used for atomizing the oil and for metering the amount of water used for the water cooled shafts of the furnace, a recording thermometer for recording the temperature of the water leaving the shafts, and recording pressure gauges for observing the constancy of the steam pressure on the lines to the furnace burners were furnished by the Brown Instrument Company.

In connection with this automatic control we have accomplished something that a great many people believe is impossible. The control equipment when working on the oil and steam has acted so accurately that the pyrometer readings on the automatic pyrometers show an absolutely straight line over a long period of time, showing that it is possible to control steam atomized oil as easily as gas.

The recording pyrometers were of the Leeds & Northrup potentiometer type.

Driving Mechanism

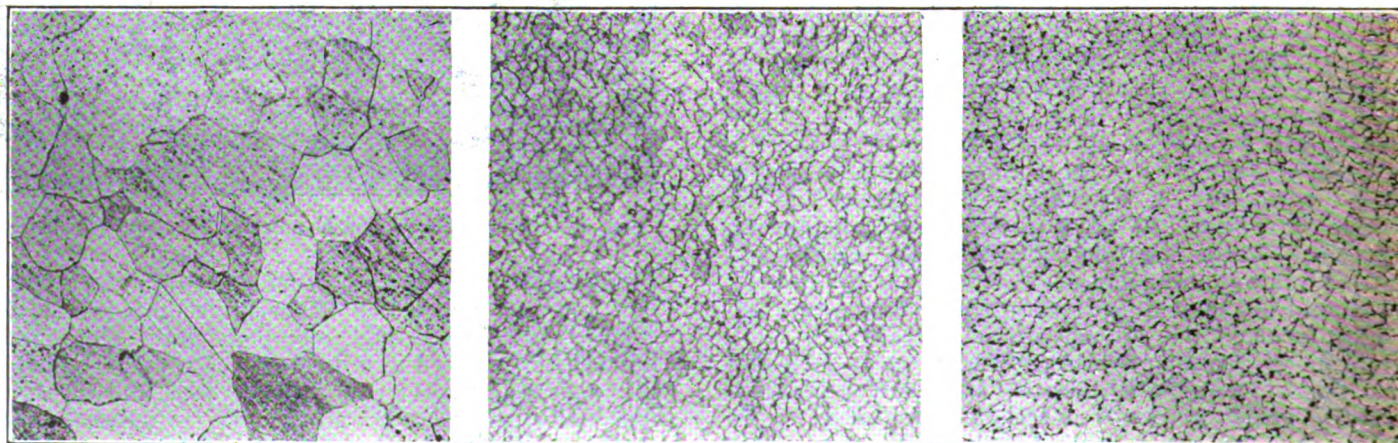
On one end of each shaft is mounted a sprocket over which runs a chain of the roller type. This is driven by a main drive sprocket at the discharge end of the furnace, which is connected up with a spur gear speed reducer driven by a variable speed motor. The return chain is carried back along a channel just under the sprockets. The first and last rolls of the furnace have auxiliary chains which drive the roll tables provided at each end of the furnace. This means that with one drive we are driving all the rolls of a furnace 155 ft. long and 15 ft. of roll table. This, we believe, is a record and we know of no other normalizing furnace in the country nearly as long, driven with a single chain drive. Up to this time about the longest continuous normalizing furnace that had been erected was about 100 ft. and most of these were gear driven. As far as I know the longest chain driven furnace that was in operation at this time was in the plant of the Sharon Steel Hoop Company at Youngstown and was about 50 ft. long.

The weight of these shafts is in the neighborhood of 900 lbs. each and, there being 126 shafts in the furnace, you can easily see that there is quite a mass to be handled by this one chain. By means of the variable speed motor it is possible to produce speeds in this furnace varying from 9 ft. per min. to 36 ft. per minute. This is necessary in order to take care of a wide variation in the gauges of sheets to be handled.

Advantages in Operation

In operating a furnace of this type there are several points of advantage as follows:

1—The thorough insulation of the furnace gives a uniform heat throughout the heating chamber from a point well below the sheet level to the crown of the



Box-double anneal
Rockwell 43.25

Normalized and box anneal,
Rockwell 59.5

Normalized only, longitudinal,
Rockwell 46.2

FIG. 4—Showing structures that may be obtained by manipulating the Kathner furnace. Magnification 100X.

TABLE I—OUTPUT IN TONS OF 2,000 LBS. WIDTHS SHOWN, 16 GAUGE.

16 Gauge Sheets or Their Proportionate Equivalent	50 ft. Heating Zone 50 ft. Cooling Zone 36 Burners			75 ft. Heating Zone 80 ft. Cooling Zone 48 Burners		
	Rate of 15 ft. per minute			Rate of 22 ft. per minute		
	Per Hour	Per Day (24 hr.)	Per 28 Days	Per Hour	Per Day (24 hr.)	Per 28 Days
20 in. wide—Double Row	3.56	85	2380	5.34	128	3584
22 in. wide—Double Row	3.85	92	2570	5.77	138	3864
24 in. wide—Double Row	4.17	100	2800	6.25	150	4200
26 in. wide—Double Row	4.46	107	2996	6.69	160	4480
28 in. wide—Double Row	4.82	115	3220	7.26	170	4842
30 in. wide—Single Row	2.6	62	1736	3.9	93	2604
32 in. wide—Single Row	2.78	66	1848	4.17	100	2800
34 in. wide—Single Row	2.9	69	1932	4.35	105	2940
36 in. wide—Single Row	3.1	74	2072	4.65	111	3108
38 in. wide—Single Row	3.28	78	2184	4.92	118	3304
40 in. wide—Single Row	3.56	85	2380	5.34	128	3584
42 in. wide—Single Row	3.6	86	2408	5.4	130	3640
44 in. wide—Single Row	3.85	92	2570	5.77	138	3864
46 in. wide—Single Row	4.	96	2688	6.	144	4032
48 in. wide—Single Row	4.17	100	2800	6.25	150	4200
50 in. wide—Single Row	4.4	105	2940	6.6	158	4424
52 in. wide—Single Row	4.46	107	2996	6.69	160	4480
54 in. wide—Single Row	4.64	111	3108	6.96	167	4676
56 in. wide—Single Row	4.82	115	3220	7.26	170	4842

furnace. This insures the thorough normalizing of the sheet and a uniformity of product.

2—This furnace, due to its thorough insulation, operates on a small quantity of fuel.

3—The sectional type of construction eliminates distortion of the furnace from expansion.

4—The sectional type of construction allows ease of access for inspection or repairs to the conveying mechanism and in time of breakdown allows one section to be removed and a shaft changed without complete shut-down with its consequent loss of heat to the whole furnace. It is possible to turn off the burners, remove one section, remove a shaft, replace it, replace the section and start the furnace up again within a couple of hours, with very little loss of heat in the furnace.

5—The insulation of the shafts reduces the water consumption to a minimum. In this type of construction we use a maximum of about 40 gals. of water per shaft per hour.

6—It is possible to control the temperature very accurately by means of the stack and door in conjunction with the automatic control, thereby insuring uniform product.

With a furnace of this type it is possible to obtain practically all results that are obtained by box anneal, except the bright or white anneal. It is also possible to give the first anneal of what is known as the "double box anneal" in this furnace. This means that a plant can eliminate considerable of their box annealing, thereby releasing capital that is now tied up in annealing boxes, as the quantity needed can be reduced considerably. In addition it saves considerable time and labor and assures more uniform results.

What is commonly known as a standard box anneal can be obtained in this furnace by simply increasing the speed of the sheet approximately 15 to 20 per cent through the furnace over that used for normalizing. It is possible to get even finer grain structures, depending upon the method of operating the furnace. The Table I shows the output in tons of 2,000 lbs. of 15 gauge sheets of various widths. These figures are based on actual runs and are conservative. They, of course, do not take into consideration the fact that for

certain grades of sheets it is necessary to use a waster to eliminate scratching. If you take four-fifths of these figures they will be approximately what you would get for full finish sheets with a waster.

Based on several months operation at Weirton, W. Va., Mr. Kathner found that it was possible to normalize sheets with 5,525 cu. ft. of coke oven gas per ton of sheets, or at 10 cents per 1,000 cu. ft., or 55 cents per ton for fuel only. Using natural gas at 45 cents per 1,000 cu. ft. this would be equivalent to a fuel cost of \$1.23. These figures have not taken into consideration labor. If you assume a foreman at 65 cents per hour and three laborers at 47½ cents per hour, it will average around 57 cents per ton. Assuming that 10 cents per ton for overhead and 30 cents per ton for interest on investment and depreciation, it gives a net cost of \$1.52 per ton with coke-oven gas, or \$2.20 for 45-cent natural gas.

With oil these figures would be slightly higher. It should be possible to normalize with less than 25 gals. of 35 Be. oil per ton which, at 7½ cents per gal., equals \$1.88 for fuel or a net of \$2.28 per ton.

These figures are, we believe, conservative and can be bettered, especially with wide sheets.

We have not taken into consideration any saving due to the fact that the majority of the material that goes through these furnaces does not require roller leveling and this is a saving that should be credited up to these furnaces. We believe that it is not possible to make a standard furnace that meets all requirements, consequently we treat each individual furnace as a problem in itself. It is possible by lengthening these furnaces to handle even larger quantities with the same labor charges. This, of course, tends to cut down the labor cost per ton.

U. S. Steel Research Building

The United States Steel Corporation will shortly determine a location for the building to house its recently organized research department. It is considered likely this department will be located at some isolated point in the east. Dr. John Johnston, formerly of Yale University, is head of the new research department.

Waste Profits as they Relate to Steel*

A Recital of Features, Both General and Particular, Which Have
a Bearing on the Betterment of the Steel and Allied In-
dustries—Elimination of Waste Paramount

By CHARLES F. ABBOTT†

IT is estimated that industrial waste in this country is causing an annual loss of \$40,000,000,000. Of this waste, well over 50 per cent is preventable. Fully 20 per cent could be saved if industry would take the obvious steps to minimize wasteful operation, standardize products, and utilize equipment and materials to the maximum.

The steel industry must plead guilty to being responsible for a considerable proportion of our annual industrial waste. Listen to what Charles M. Schwab, chairman of the Board of the Bethlehem Steel Corporation, and President of the American Iron and Steel Institute, has to say on this subject:

"There is one thing that we must get into our minds. We have spent vast sums in the development of our plants and the economies of operation. The Bethlehem Steel Corporation has spent \$167,000,000 in four years in the development of our plants. We have made less money than we ever made before, notwithstanding the vast savings made in that direction. We have given away in other directions all the savings that we made in this vast expenditure of capital."

In the steel industry, and in other industries, waste in methods of production is being attacked with vigor and success. It is in the field of distribution that the greatest waste prevails at the present time. We have not yet learned the importance of standardizing the product in accordance with the consumer's needs, nor do we give due consideration to the development of new uses or to those factors that influence the sales of the product at a fair profit.

What possible benefit can follow the production by the rolling mills of continuously varying designs and dimensions of structural shapes? To do so adds to the difficulties of producer, fabricator, designer, and purchaser. Real service on the part of the producer is evident when he is able to offer a product which reduces to a minimum the time and thought that must be expended by the buyer in making his purchase and using the product in the most effective manner.

The American Institute of Steel Construction is now actively engaged in a campaign to eliminate the wastes which I have enumerated. Progress has been made, but much remains to be done, both by the structural steel industry and the producers of steel whose co-operation is essential in any such far-reaching program. Similar wastes exist in other branches of the industry, and in some of the branches similar efforts are being made to eliminate them. Again much remains to be done.

In October 1921, the enormous waste in distribution was called to the attention of business men and the general public by the Joint Committee on Marketing

and Distribution of the Sixty-seventh Congress. The report of the committee stated that we have now reached a point where it costs more to distribute and serve than to produce.

Among the principle causes of the high cost of distribution, Secretary Hoover mentioned the following:

- 1—Lack of information of national stocks, of production, and of consumption.
- 2—Lack of standards of quality and grades.
- 3—Lack of uniformity of business practices in terms and documents.
- 4—Disorderly marketing.
- 5—Destructive competition.

These causes fall naturally into two separate classifications. The first four can be grouped as tangible, physical causes of waste. The remedies, too, are tangible, or physical, whichever you wish to call them. Destructive competition falls under a different heading. This is a spiritual cause of waste in the sense that it is an intangible phenomenon due to defects in mental attitudes. Here the remedy must be largely educational.

Research has proved one of the most effective means of reducing the tangible causes back of the wholesale squandering of our opportunities for more profitable business. Profits depend largely upon continuous research. Reduced costs, improvement in quality, and new uses are among the possibilities. With no improvements in its product, no new uses, a concern or an industry is stalemated.

It is stated that the automobile industry now saves a \$1,000,000,000 annually, due to standardization based on research. A dozen years ago the waste in many of the materials used in the manufacture of a car was almost as great as the amount of the materials finally incorporated in the finished automobile. Much of the progress that has been made can be attributed to the campaign against waste in industry organized by the Department of Commerce.

The same department can be of great assistance to any industry, but its help should follow an organized effort within the industry. It is not the function of the Department to take the lead or to exert pressure on any industry. Each industry should initiate its own program of standardization and simplification, and make its own decisions in all matters vital to its welfare.

Research furnished an essential part of the data required for the Standard Specification for Structural Steel for Buildings, and the Standard Specification for Fireproofing Structural Steel Buildings, formulated by committees appointed by the American Institute of Steel Construction. The first specification is effecting a saving of about 10 per cent of the amount of steel required for any steel-frame building in those cities in which its use has been authorized. The fireproofing specifications reduces costs by eliminating the unnecessary dead loads demanded by obsolete fireproofing methods.

*Abstract of address at the fourth annual meeting of the Iron, Steel and Allied Industries of California, February 18, 1928.

†Director, American Institute of Steel Construction.

At the present time, steel is suffering a serious displacement in the field of highway bridge construction. The public is being educated to believe that steel bridges are unsightly, expensive, and lacking in durability. In Pennsylvania it is next to impossible to erect a steel highway bridge, because those in control hold that—

"There are two conditions under which steel is justified:

First—When the span and height are such as to make concrete impracticable,

Second—Where there is no way to get the additional funds required for concrete. The justification for this position is in the fact that there is no economy in a steel bridge and public funds should, if at all possible, be spent for non-perishable improvements."

It is strange that such a situation should exist in the state that is the home of the steel industry. Other states enforce restrictions favoring competition, and the number of such states is increasing.

As to the development of new uses for steel, steel roadbeds, steel railroad ties, and steel for residences provide promising fields for expansion. Steel-frame residences have already passed out of the experimental stage, but we have not yet even scratched the surface of the potential market.

An encouraging indication that the steel industry is awakening to the necessity of studying the market is given by the recent organization of a Commercial Research Department by the Colorado Fuel & Iron Company. The future sales activities of this company will be based upon accurate information as to customers, prospective customers, market possibilities, buying influences, and economic trends.

James A. Farrell, president of the United States Steel Corporation, has always advocated a general adoption of the principle of co-operation in the place of ruinous competition, as a means of bringing about more stable conditions and better profits in the steel industry. Close and mutually helpful relations between the producing mills and their intermediate industries constitute an essential step in achieving such co-operation.

The mills have a well defined responsibility in the movement of their products to the ultimate consumer. Intermediate industries, otherwise designated as distributors, are in most instances essential to efficient distribution. Public interest demands service based upon the most economical system of distribution, and responsibility for such service rests equally upon producer and distributor. It continues until the public's requirements have been adequately met.

Koppers Erects New Building

The new 32-story Koppers Building, now being erected at Pittsburgh on the southwest corner of Grant Street and Seventh Avenue, in addition to being the tallest building in Pittsburgh, will be one of the finest office buildings in America. The architects are Graham, Anderson, Probst and White, with E. P. Mellon as consulting architect.

The new structure, which will be a splendid expression of modern design and efficiency, will have the set-back style of architecture characteristic of tall buildings. The exterior of the first three floors will be granite with the remainder of the building finished in

Indiana lime stone. The main entrance from Seventh Avenue will be into a 3-story lobby, which will intercept an arcade running from Grant Street to William Penn Way, where the side entrances will be located. This lobby will be finished in Italian marble. Completion is promised for January 1, 1929.

The site of the building fits nicely into the new Crosstown City Planning Scheme, is easily accessible to the Union Station, principal car and bus lines, the



boulevards and the proposed new post office. It will have a frontage of 196 ft. on Seventh Avenue, with 90 ft. of depth on Grant Street and William Penn Way.

The new building was designed primarily to meet the growing needs of the Koppers Company, which will occupy the fourth to fifteenth floors, the balance of the space being available for desirable tenants.

The Koppers Company, which came to Pittsburgh in 1915, is one of America's largest industrials, being engaged in erecting, owning and operating by-product coke and gas plants in this and other countries. According to officials, the new Koppers Building, in addition to meeting the company's practical requirements will be an expression of its faith in the future growth and prosperity of Pittsburgh.

The POWER PLANT

Utilizing Waste Heat by Means of Boilers*

An Appraisal of the Economies to be Derived by Extracting Heat from the Spent Gases from Engines, Producers, and Furnaces—New Type of Boiler Presented

STEAM boilers have hitherto constituted the most efficient means of utilizing the heat contained in flue gases, down to temperatures of 250 to 300 deg. C. At these temperatures the waste or exhaust gases usually contain about 15 to 25 per cent of the total heat originally available in the coal burnt. If the waste gases are now utilized further, say, for heating the feed water or the air needed for combustion, the total efficiency of the boiler plant may easily be increased to as much as 85 per cent. With internal combustion engines, however, the position is wholly different, and the same applies to industrial furnaces and ovens, gas producers, etc. Here it is not possible to make direct use of the recoverable waste heat within the limits of the main plant. Until quite recently, it was therefore a general practice to let all the valuable heat of the high-temperature exhaust gases simply escape with the latter, although a large proportion of the heat thus wasted could have been recovered and utilized by the aid of waste-heat boilers generating steam that could have been employed for heating as well as for power purposes. In the case of internal combustion engines and producers the waste heat could have been recovered in the cooling jackets. The savings to be obtained by such methods are often very substantial and may be anything up to 50 per cent of the original calorific value of the fuel used, depending upon the nature of the plan. It is obvious that such potential savings may make the economic position of many a works or plant assume an entirely new light.

Smoke Tube Boilers

Smoke-tube boilers are practically the only kind nowadays used as waste-heat boilers in connection with internal combustion engines and producers, whereas industrial furnaces and ovens can be combined with all types of boiler as waste-heat boilers. In waste-heat boilers the waste gases heating them are usually cooled down to a temperature of about 150 to 180 deg. C. which is sufficient to ensure that the acid components of the heating gases—sulphur dioxide, etc.—will escape in a satisfactory manner. This is necessary because, if the temperature were lower, the colder parts of the boiler might cause the acid components to condense on them, together with the water contained in the waste gases, ultimately inducing pitting and corrosion. As the ascension of the gases alone is no longer able to supply adequate draught in the smoke-stack at such low temperatures, waste-heat boilers heated by waste gases from industrial furnaces

have to be provided with induced draught fans. The working of the whole furnace plant thus becomes much more uniform, and the furnace output much higher than if ordinary chimney draught were employed without utilization of the waste heat. The power consumption of the fan is exceedingly small and does not amount to more than about one-twelfth of the total energy recovered by the aid of the waste-heat boiler. With internal combustion engines the natural velocity at which the waste gases are exhausted suffices completely to force them through the waste-heat boiler.

Vertical boilers demand perfect feed water, i.e., water that has been softened previously and which contains no sludge, as leakages at points where the tubes are beaded in are liable to result if incrustations or sediments begin to settle on the lower tube plate.

Fig. 1 shows a horizontal waste-heat boiler with superheater and feed heater. The waste gases travel first through the superheater, then once only through the boiler proper, and finally through the feed water heater. Owing to the great simplicity of the path followed, the resistance to be overcome by the waste

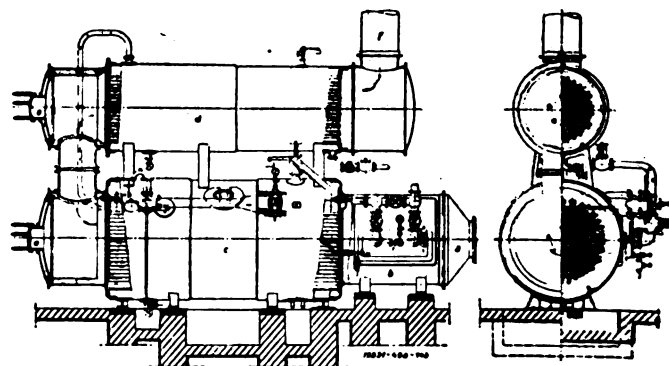


FIG. 1—Waste-heat boiler. a = gas admission flange, b = superheater, c = waste-heat boiler, d = feed heater, f = chimney.

gases on their way is very low indeed. At present these waste-heat boilers can be supplied for any pressure up to 441 lbs. per sq. in. (31 ats.) abs. They are equipped with all the necessary safety devices to ensure absolute reliability and security when in operation. The comparatively large water space of the boilers renders them to a certain extent independent of moderate fluctuations occurring in the working of the plant that supplies the waste gases serving to heat them. Besides, the large water space referred to makes it possible to take supplies of steam from the

*Demag News.

boilers to cover temporary peak demands greater than the amount of steam which corresponds to the mean quantity of waste heat actually available. If steam is required from the waste-heat boiler, for prolonged periods during which no waste gases reach the waste-heat boiler, the latter must be fitted with an auxiliary furnace burning gas or oil fuel with the aid of special burners, or some other fuel. This auxiliary furnace continues to heat the waste-heat boiler until an adequate supply of waste gases is again available.

Waste Heat in Gases

The quantities of waste heat that can be recovered from the exhaust gases and the cooling water of large gas engines, are very considerable. In utilizing the heat of the exhaust gases it was found best to combine a separate waste-heat boiler with each individual engine, because in this way every boiler in operation can always be kept working as near full capacity as possible. On an average the exhaust gases of large gas engines contain from 30 to 32 per cent of the total calorific energy originally supplied to them by the fuel. Modern high-duty gas engines with all the latest improvements, including scavenging and after-charging, show even higher losses, their exhaust gases containing up to as much as 50 to 52 per cent of the original heat input. The exhaust gases enter the waste-heat boilers at temperatures between 400 and 750 deg. C. and leave them again at a temperature of about 150 deg. C, so that the temperature drop utilized in the waste-heat boilers varies between 250 deg. C and 600 deg. C. The returns obtained from waste-heat boilers for these inputs are between 2.65 and 3.5 lbs. (1.2 and 1.6 kg.) of steam for 1 kwh. and 1.98 and 2.65 lbs. (0.9 and 1.2 kg.) of steam for 1 eff.-hp. per hr. generated and delivered by the gas-engine and dynamo aggregate. A turbo-generator set using the steam thus produced could very well deliver a supplementary output amounting to 0.27 to 0.34 kw.-hrs. The efficiency of high-duty gas engines in point of fuel utilization measured at the switch-board, thus rises from 22 per cent, when working without waste-heat boilers, to 32 per cent with utilization of the waste-heat, the gas engine in both cases generating electricity. If the steam from the waste-heat boilers is not used for power purposes, but entirely for heating and boiling, say, in chemical works, the total heat utilization may increase to almost 70 per cent in all. The quantity of steam obtained in waste-heat boilers, from high-duty gas engines of 5,440 bhp., for example, equals the output of a direct-fired boiler plant consuming about 0.8 tons of coal per hour.

Large gas engines without utilization of the exhaust gases are an exception in modern engineering plants nowadays, and even existing older plants are now frequently supplemented by the installation of waste-heat boilers. The latter also make use of the excess heat consumed by the engine through incomplete combustion, or through the scavenging process in the case of two-stroke-cycle engines, this extra consumption of heat mostly manifesting itself in the form of higher temperatures of the exhaust gases.

Smoke-tube waste-heat boilers are also frequently used in combination with industrial furnaces. Although water-tube boilers were at first employed almost exclusively in the U. S. A., that country has since likewise recognized the vast superiority of smoketube boilers, a superiority which is due to their great strength in resisting the effects of explosions occur-

ring in the waste-gas mains, their accessibility and the ease with which they can be cleaned, their higher efficiency, their compactness which enables them to take up less room, their lower initial cost, and the avoidance of leakages, through which cold air may gain access to the boiler flues.

Fig. 2 shows a section of an open-hearth steel shop with six induced-draught waste-heat boilers combined with the furnaces. According to the temperature gradient available, the waste gases of the

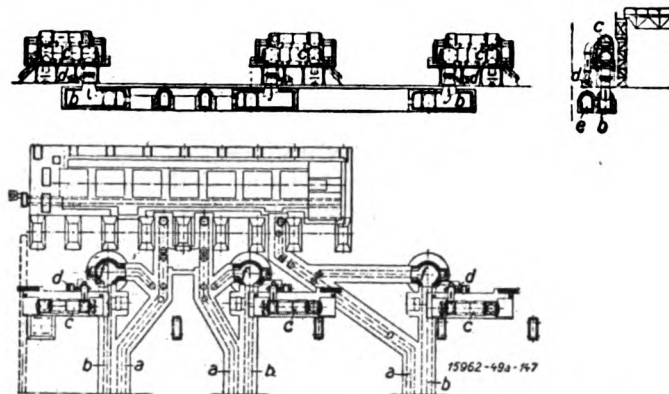


FIG. 2—Section of an open-hearth steel shop with six waste-heat boilers working in conjunction with 40 and 80-ton open-hearth furnaces. a = gas flue, b = waste gas channel, c = waste-heat boiler, d = electric fan, e = flue, f = chimney.

open-hearth furnaces furnish between 820 and 1,210 lbs. (375 and 550 kg.) of steam of 213 to 512 lbs. pressure per sq. in. (15 to 36 ats.) abs., superheated to a temperature of 350 deg. C., for every ton of finished steel produced.

Extraordinary savings can on the same lines also be achieved in connection with ingot reheating furnaces, annealing and reheating furnaces, smelting furnaces, forge furnaces, etc.

Still more favorable results can be obtained with the furnaces in the ceramic industries, and with furnaces in cement and glass works. Gases of combustion having temperatures lower than 1000 deg. C. are generally of no further use in these furnaces. Most of the waste gases leaving them consequently contain quantities of heat much in excess of those turned to useful account in the furnace process. The utilization of all the heat escaping in the waste gases of these industries constitutes a rich field for exploitation with the aid of waste-heat boilers.

Heat from Producers

In the case of producers designed to gasify fuel making much slags, and having water-cooled double-shell jackets at the lower end of the furnace shafts to prevent the slags from clinkering and facilitate work with the pokers, it was natural that the idea of using the hot cooling water for the production of steam and hot water should suggest itself. The temperature of the cooling water in the jacket rises to about 60 to 70 deg. C., the water flowing out at the top of the jacket at this temperature without being utilized. The heat contained in the cooling water comes from the red-hot layer of fuel in the furnace and must be considered a dead loss if not made use of in some way or another. The loss is between 4 and 7 per cent of the calorific value of the coal, according to the height of the jacketing. As the gasification process

requires steam to be added to the gasification air, the jackets were eventually designed as low pressure boilers. The first producers possessing steam jackets (Fig. 3) were built and delivered in 1909, and still continue to work satisfactorily.

Producers with steam jackets found application in ever increasing numbers when the gasification of small coke began to spread, gas works being the chief promoters of the developments in this direction. Nowadays the producer jacket is either designed for high pressure or low pressure steam, according to the purposes for which the steam generated is to be used. The surplus steam, i.e., the steam generated in the jacket in excess of that required by the producer for its own consumption, amounts to something like 0.5 lbs. per 1 lb. of fuel. Altogether about 0.8 lbs. of steam are produced in the jacketing for every 1 lb. of coal gasified, the heat contents of the steam produced being about 8 per cent of the calorific value of the fuel gasified.

The gases made in the producer contain a large amount of heat when they leave it. If they are to be used for heating purposes, reaching the furnaces while still hot, the utilization of their sensible heat causes no further difficulties. But the case is different if the producer gas has to be cleaned and scoured

a waste-heat boiler between the cooler-scourer and the producer. At this point the waste-heat boiler recovers almost all the waste-heat otherwise lost in the scourer.

A plant on these lines has been built for a gas works. The plant is illustrated in Fig. 4. It consists of four producers with rotary grates, each producer

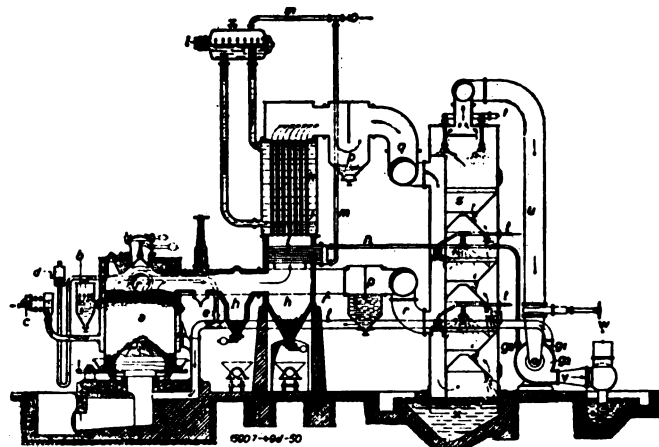


FIG. 4—Diagram of the producer plant.

having a clear internal shaft diameter of 9 ft. 11 in. (3 m.) and steam jacketing. The producers are arranged in a circle around a vertical waste-heat boiler in the center and connected with the latter by radial producer gas delivery pipes which contain dust collectors. The lower part of the waste-heat boiler is likewise designed as a dust collector which allows of its being emptied while the plant is working. The waste-heat boiler itself is a vertical smoke-tube boiler headed by a superheater. Any producer can be shut off separately from the waste-heat boiler by means of sluice-valves cutting off the delivery of heating gas. In the event of the waste-heat boiler being stopped entirely, the producer gas can reach the two cooling scourers by direct connections.

A centrifugal blower supplies the producers with the air they need for the gasification process. This centrifugal blower and a gas fan conveying the gases from the coolers to the furnaces by suction are both mounted on a common shaft. The plant possesses two such blower aggregates, one of which is driven by a three-phase a.c. motor, while the other one is coupled with a steam turbine using steam supplied by the waste heat boiler. One of these double blower sets acts as a standby for emergencies.

Combustion Gets \$2,500,000 Contract

George E. Learnard, president of International Combustion Engineering Corporation, has announced the receipt of cable advices from his British subsidiary, International Combustion, Ltd., advising of the closing of an order with the Synthetic Ammonia and Nitrates, Ltd., at Billingham-on-Tees, England, for the largest high pressure boiler plant in the world, upon which work will proceed immediately.

International Combustion, Ltd., will build all of the equipment going into this plant, including high pressure steam generating units, of which there will be six of 800-lb. pressure, with a generating capacity of 269,000 lbs. each.

The plant is designed to burn pulverized coal and International Combustion's Lopulco Systems for the preparation and burning of the coal has been ordered.

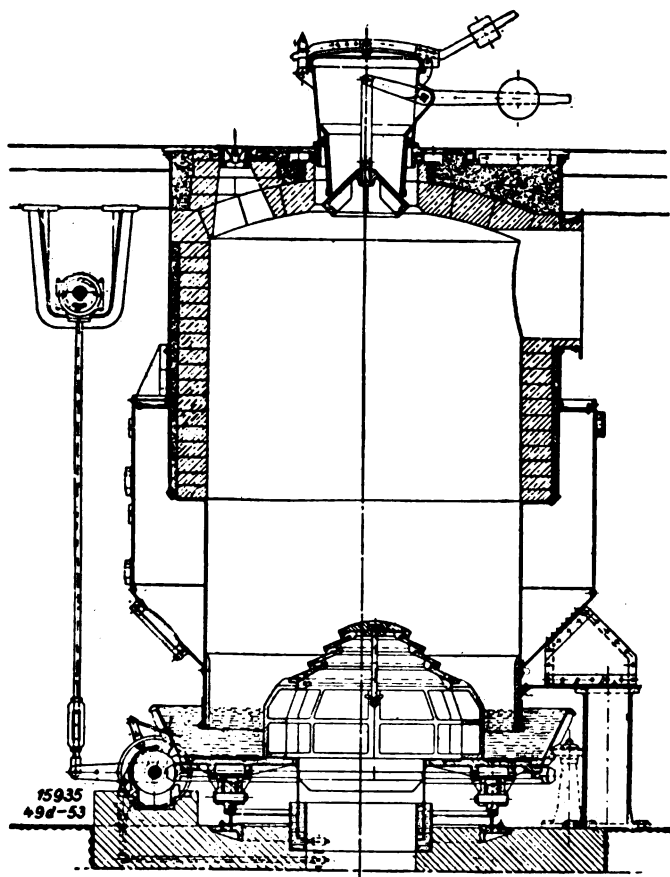


FIG. 3—Producer with steam jacket built in 1909.

prior to combustion, its temperature in that case dropping from about 400 or 500 deg. C. to, say, 30 deg. C., with the result that about 8 per cent of the calorific value of the coal is lost in consequence. As this heat cannot be utilized in the producer process itself, there is no alternative but to use it for other purposes in order to increase the thermal efficiency of the producers as a whole. This can be done by interpolating

Furnace Design for High Capacity*

Furnace Operation Is Here Set Forth as It Is Found in Plants of Modern Design—Construction of Furnace Walls, Bottoms, etc., Have Important Bearing on Combustion and Overall Economy

By E. G. BAILEY†

PART II

THE marine-type water-tube boiler is shown in Fig. 8 supplied from a direct-firing mill with two turbulent burners patterned very much after a mechanical oil burner. When burning coal with a fusing temperature of 2,700 deg. F., it has operated continuously at over 60,000 Btu. per cu. ft. of furnace volume per hour.

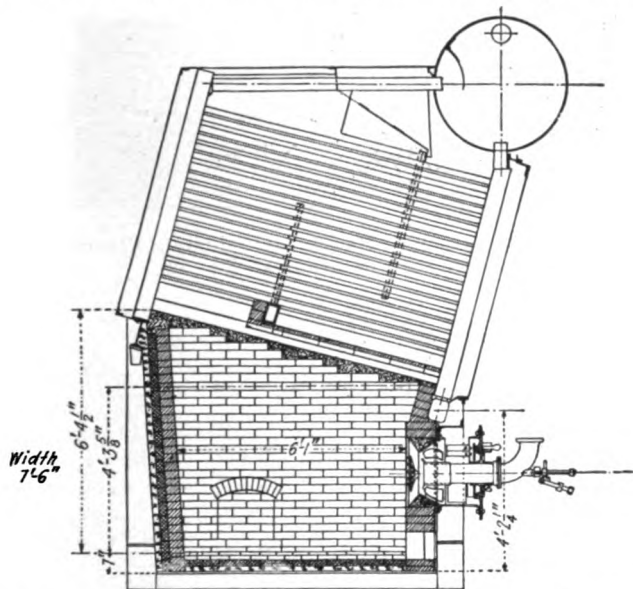


FIG. 8—Section of furnace at Babcock & Wilcox Company, Bayonne, N. J., fired with pulverized coal using two mechanical oil burners converted into turbulent coal burners. Reference B in Table I and Fig. 3.

Tests have been run with rates of combustion as high as 75,000 Btu. per cu. ft. per hour with 38 per cent excess air and without any undesirable clinker on side walls, floor, and boiler tubes. The ash was readily removed while in operation by merely scraping it off the floor. The results are given in Table 1 and plotted in Fig. 3 as point B. This furnace has a fraction cold of 0.20, which with the steepness of the ψ curve at 2,700 deg. would account for a great difference between it and the Columbia Power furnace previously described. This very phenomenal operating condition is probably due to the proximity of the cooling tubes to the burners as well as to the floor and the walls of the furnace.

There is no doubt a distance factor as well as an area factor that should be used in determining the fraction cold. In other words, the proximity of the floor, walls, and flame to the boiler tubes may add greatly to the cooling effect in the furnace. However, the two turbulent burners on this boiler are extremely effective, and they produce practically transparent flame so that there is little to obstruct the radiant heat of the floor

and walls in passing directly to the cooling tubes. The flame from these burners does not impinge on the walls. It is evident that this particular operation requires more than passing comment, as it ranks well above any other rate of combustion with pulverized coal and exceeds that in most modern stoker-fired furnaces, as well as those in furnace burning oil and gas.

A coal having an ash fusing point of 2,000 deg. F. was burned in this furnace at a rate of about 60,000 Btu. per cu. ft. per hour with very poor results. The ash slagged between the tubes and ran down the walls on to the floor, making a dense mass that was impossible to remove while in operation and had to be chipped out after the boiler was out of service. This indicates conclusively that coal having ash with a high fusing point is absolutely necessary to meet these operating conditions. Following the ψ curve down from

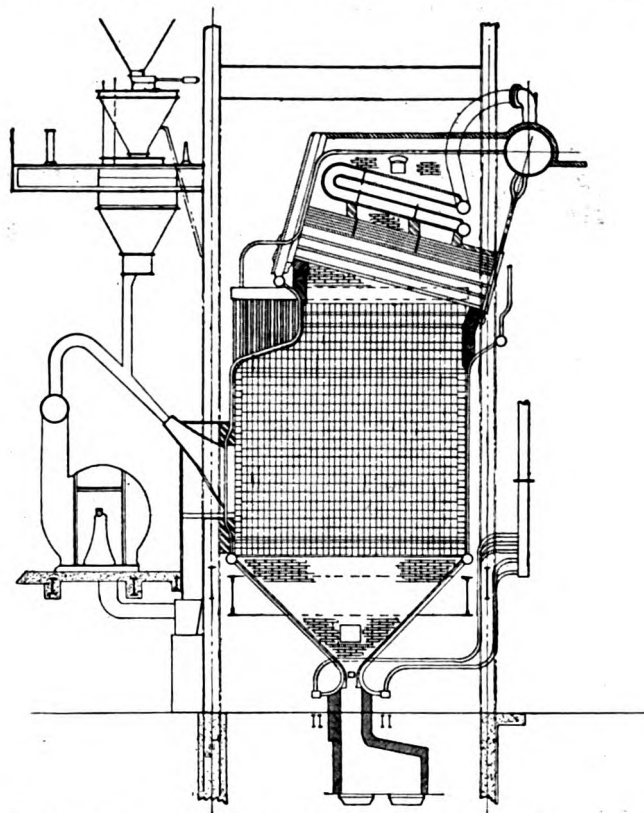


FIG. 9—Section of water-cooled furnace, boiler No. 22 at Calumet Station of Commonwealth Edison Company, fired with pulverized coal using eight Calumet burners. Reference 63 in Table I and Figs. 2 and 3.

point B it is obvious that with a fusing temperature of 2,000 deg. F. this boiler should operate at a combustion rate of about 10,000 Btu. per cu. ft. per hour with 20 per cent excess air or 16,000 Btu. per cu. ft. per hour with 40 per cent excess air. A detailed report of tests

*Abstract of paper delivered at annual meeting of the American Society of Mechanical Engineers, New York, December 5-8, 1927.

†President, Fuller-Lehigh Company.

and operation of this marine boiler is given by Stillman.⁶

Fig. 9 represents boiler No. 22 at Calumet Station, Commonwealth Edison Company, the details of which are more fully described in the Prime Mover Committee Report,⁴ and by Dr. Jacobus.⁷

The results from this furnace are plotted in Fig. 2 as point 63, on the basis of a total steam generation of 250,000 lb. per hour. The boiler has generated 285,000 lb. per hour, which would bring the rate of combustion up to 30,000 Btu. per cu. ft. per hour, this having been accomplished with coal having a fusing point of ash of 1,850 deg. F.

The ash from this coal not only has a very low fusing point, but is very fluid and destructive when molten. The two triangular ends of the ash hopper are solid brick walls, and are wasting away from the molten slag.

This furnace is equipped with eight Calumet burners, and has operated very satisfactorily at around

Inspection doors near the bottom of this furnace give an excellent opportunity to study various phases of slag formation and action. At the higher ratings molten slag is continuously running down all four

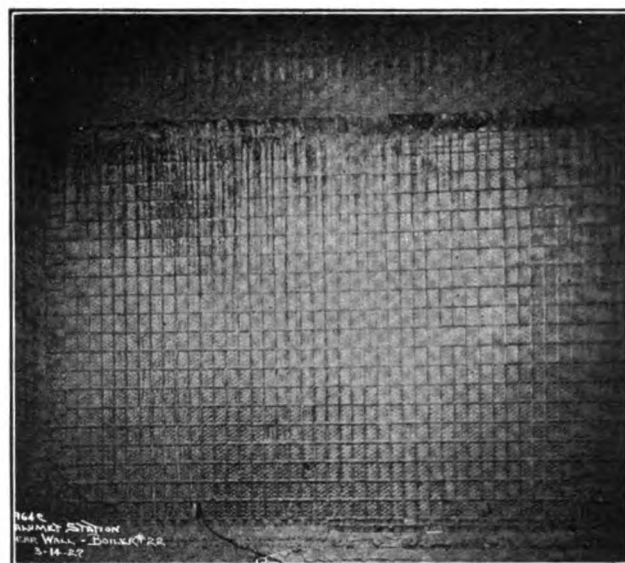


FIG. 11—Back wall of furnace at Calumet. Photograph taken at same time as Fig. 10.

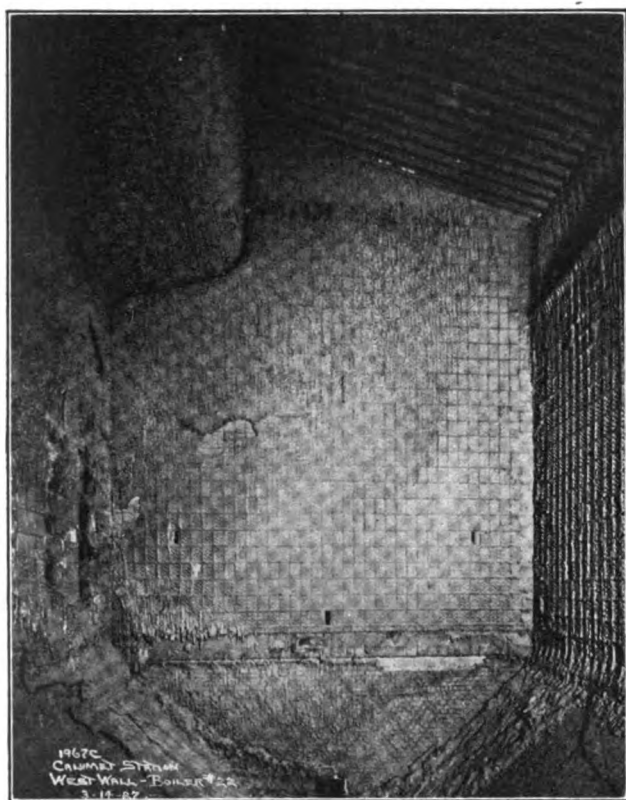


FIG. 10—Side wall of furnace at Calumet Station, showing Calumet burner openings, hopper-bottomed floor, and furnace condition after several months' operation.

20,000 Btu. per cu. ft. per hour in normal operation, and as high as 25,000 to 30,000 Btu. per cu. ft. per hour with 25 per cent excess air. This furnace has a fraction cold of 0.90 and has operated up to about half the rate corresponding to the ψ curve. Figs. 10 and 11 show the side and rear walls, respectively, and are from photographs taken after several months' operation.

⁶T. B. Stillman, "Tests Using Pulverized Coal Under Marine Water-Tube Boiler," read before the Society of Naval Architects and Marine Engineers, November 11, 1927.

⁴National Electric Light Association, Publication No. 267-95, "Pulverized Fuel," August, 1927.

⁷D. S. Jacobus, "High Pressure Boiler Developments," read before Engineers' Society of Western Pennsylvania, October 17, 1927.

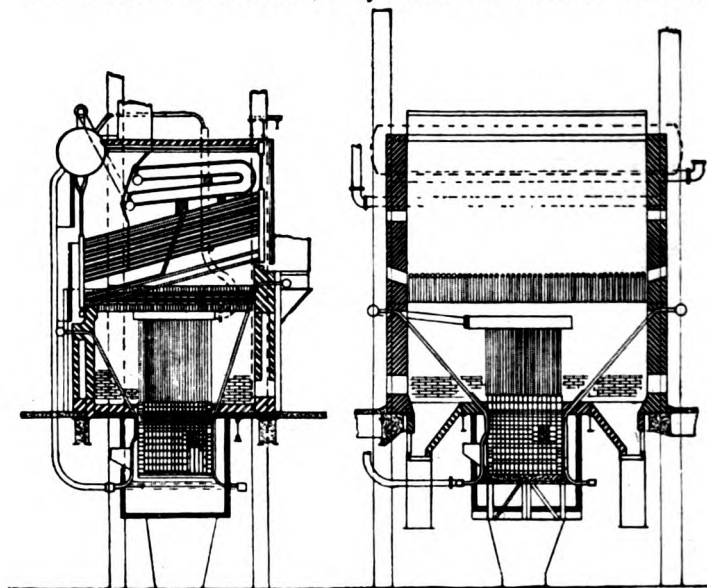


FIG. 12—Section of well furnace, boiler No. 13, Charles R. Huntley Station, Buffalo General Electric Company, as now operating with four Calumet burners arranged tangentially in a well 8 ft. square. Reference 85b in Table I and Figs. 2 and 3.

eaves of a roof, and it can be readily broken off and the throat kept free.

Another interesting phenomenon is the continual dropping of ash from the boiler tubes. The molten particles of ash carried by the gases into the boiler tubes deposit and chill until large enough to break

and drop off in chunks from $\frac{1}{2}$ in. to 2 in. in size. These are soft and molten by the time they reach the floor after dropping through the central part of the hot furnace. It is such accumulation as this that makes it difficult to remove ash and clinker from a refractory-covered floor or hopper bottom after these particles have built up into a solid adhesive mass.

Fig. 12 shows the well furnace 8 ft. square at the Charles R. Huntley Station of the Buffalo General Electric Company after some changes from the original design were made. The latter as well as some efficiency results during the early experiments are described by Cushing,⁸ who shows that boiler efficiencies increased from 65 per cent with the furnace and burners as shown in Fig. 13, to 75 per cent with the furnace as shown in Fig. 12. when operating at a combustion rate of 54,000 Btu. per cu. ft. per hour.

The earlier conception of the well furnace was to introduce pulverized coal and all of the air for combustion tangentially into a small well in which violent

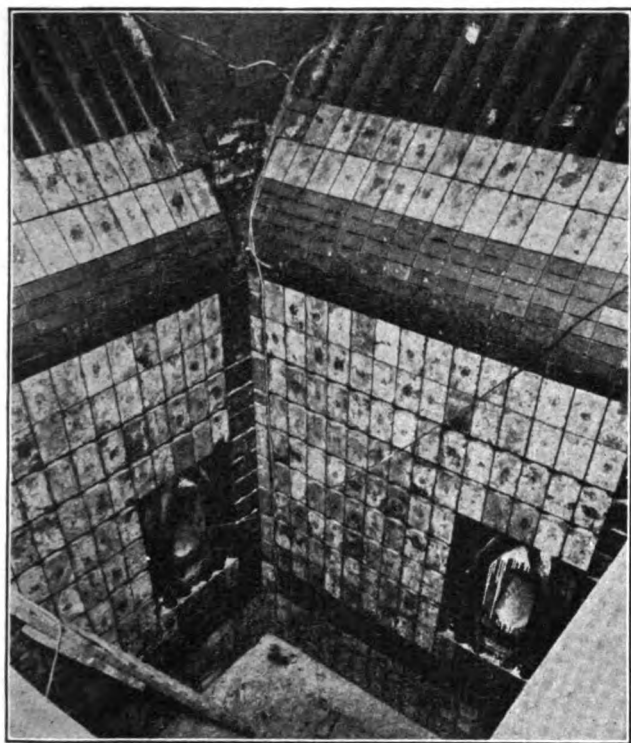


FIG. 13—View looking into 8-ft. well furnace, boiler No. 13, at Buffalo, as originally installed.

mixture would take place and combustion be completed a short distance above the top of the well. The early design called for exposed tubes backed up by carborundum tile as shown in Fig. 3 of Cushing's paper. It was anticipated that the rates of heat transfer would be terrifically high in such a furnace, probably exceeding 200,000 Btu. per sq. ft. of wall area per hour, and that the tubes could not withstand such punishment, so that water-cooled refractory-faced blocks were suggested as the best-known lining for such conditions. But as it was desired to keep the well proper as cool as possible to prevent the slagging of the ash and as this installation was of an experi-

⁸Cushing and Moore, "Direct-Fired Powdered-Fuel Boilers with Well-Type Furnace at Charles R. Huntley Station," presented at the First National Fuels Meeting of the A.S.M.E., St. Louis, Mo., October 11, 1927.

mental nature, bare steel and cast-iron blocks as shown in Fig. 13, were first installed. These blocks were calorized, but even with that precaution and the best contact between the block and the tube known at that time, the temperature and the blast action of direct flame impingement at 120 ft. per sec. were too great and the blocks had a relatively short life. Molten ash accumulated in a pool in the lower part of the well and was tapped out intermittently.

The velocities were so high and the volume of gases so great that the rotating or tangential action which was expected was not obtained. The gases took a high vertical velocity, leaving the well at about 100 ft. per sec., and consequently rotated only slightly more than 90 deg. around the well before escaping. Homogeneous mixture was not obtained under these conditions and a new burner was built in which all of the air was mixed as quickly as possible with the coal as it entered the furnace. Provision was also made for a more uniform division of coal and air from each mill to the two burners. Refractory-faced blocks were also installed, and the boiler operated at rates of evaporation of from 200,000 to 225,000 lb. per hour. The better efficiencies previously mentioned were obtained and the molten slag which streamed down over the walls into the well was successfully handled, but the punishment was too great for this wall construction and the efficiency was too low due to carbon loss and incomplete combustion. The rate of combustion per hour was from 50,000 to 60,000 Btu. per cu. ft. of total furnace volume above the flaring wall tubes, but the high velocity of gases passing directly from the well to the boiler tubes did not permit the gases to spread out into this entire volume, and it is estimated that the volume occupied by the active combustion gave rates as high as 100,000 Btu. per cu. ft. per hour.

The Coal Market

With coal stocks in industries in the United States and Canada dropping off slightly over 3,000,000 tons and consumption per day remaining about the same as January, production ran slightly lower per day than the preceding month. Number of days' supply of coal on hand as of March 1, 1928, amounted to 38 days as compared with 43 days supply a year ago. Consumption of coal is still running considerably under last year's consumption and stocks are 28 per cent lower than a year ago.

Consumption of bituminous coal during the month of January this year, including all requirements—industries, retailers, exports, bunker, etc.—amounted to approximately 47,000,000 tons. So with business remaining about the same as at present, it would appear that adding to the 42,000,000 tons produced by non-union operations last year, the additional production which has been changed from union to non-union basis over this winter, there is plenty of coal available from the non-union mines to supply the entire country, year in and year out.

The number of days' supply in industries is as follows:

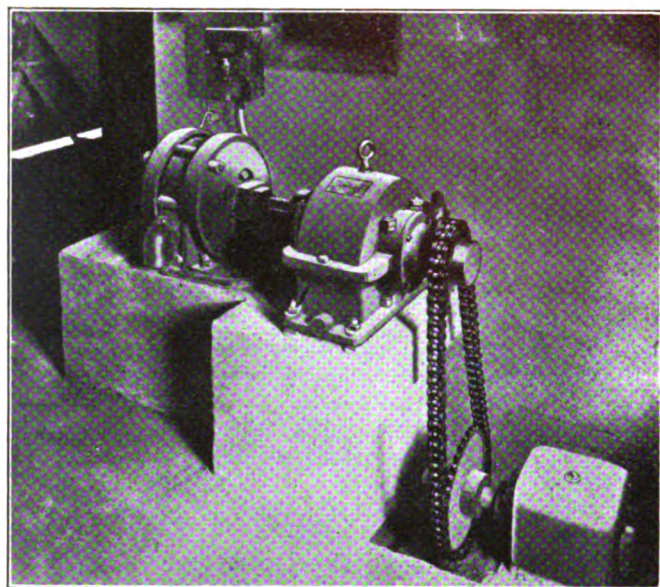
By-product coke	36 days
Electric utilities and coal gas plants	51 days
Railroads	37 days
Steel Mills	26 days
Other industries	37 days

WITH THE EQUIPMENT MANUFACTURERS

New Type Speed Reducer

This most recent type of speed reducer developed by Link-Belt, known as a type "RC" Reducer, is an installation at the plant of Huron Portland Cement Company, Detroit, a 5 hp. unit with 10 to 1 reduction from an 850-rpm. motor down to enclosed miter-gearred countershaft of the Caldwell screw conveyor it operates.

With the casing removed from the chain drive so that one may better understand the arrangement, it



can be seen that it is a simple reduction unit of low first cost and high efficiency—possessing, moreover, the fundamental advantage of an unusual flexibility in its application.

The "RC" reducer is a combination of the standard herringbone reducer from the motor or high-speed shaft, and a finished steel "RC" class roller chain drive, separately encased and running in oil, for transmitting the power from the herringbone gear unit to the driven machine.

Quigley Refractory Gun

The Quigley Bitumen Gun is designed for shooting hot or cold materials (hot tar, asphalt, pitches, enamels, heavy fluids, waxes, paraffines, etc.,) as a protective coating on metal, concrete, stone, brick, wood, cork or other surfaces. Special features of the bitumen gun are the self-contained heater, enabling ease of application regardless of temperature, and the fact that air is never mixed with the material.

There are many uses for the gun, such as waterproofing foundations and walls; applying asphalt, tar or pitch to roofs and buildings; coating the interior of water tanks, vats, reservoirs, etc.; coating water, gas and oil pipe lines; the interior and exterior of steel structures, and ships, and boot-topping. Also applying

protective coatings to such structures as penstocks, vaults, warehouse floors and walls, bridge piers and abutments, dry docks, lock gates, etc. This gun is sold by the Quigley Furnace Specialties Company, Inc., of 26 Cortlandt Street, New York City.

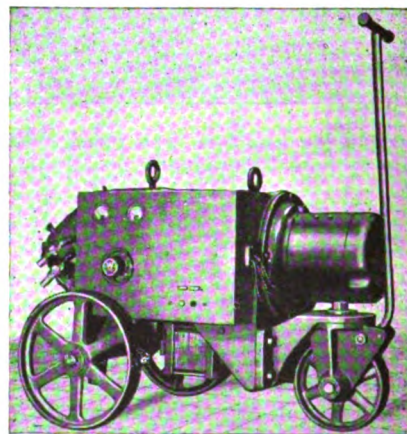
New 200 Ampere Arc-Welder

A new Westinghouse, 200 ampere, single-operator welding set has been designed to meet every requirement in both the shop and field, and to serve all applications, within its rating, with speed and economy. This new unit is outstanding in its features of simplicity of operation and compactness in construction.

The set is started by connecting directly across the line by means of a Linestarter and Linestart motor. Starting and stopping are accomplished by the simple operation of a pushbutton. A single rheostat varies the arc current over the entire welding range. Accurate adjustment over the welding range, from 60 amperes to 300 amperes, is afforded by steps of 5 amperes.

The motor-generator, and control equipment are assembled in a totally enclosed frame. The exciter, which is overhung from the motor end, is securely fastened to the unit frame. This type of construction guards the operator against injury, and protects the set from dirt and falling objects. In performance tests welding operations have been carried on while the sets were suspended at every angle that could possibly be required in any application. Operation is as satisfactory when the set is placed on end, as when it is in the normal position.

Steady welding current, insuring thorough penetration and fusion of the weld, is obtained from a constant current generator. A separate exciter is used in



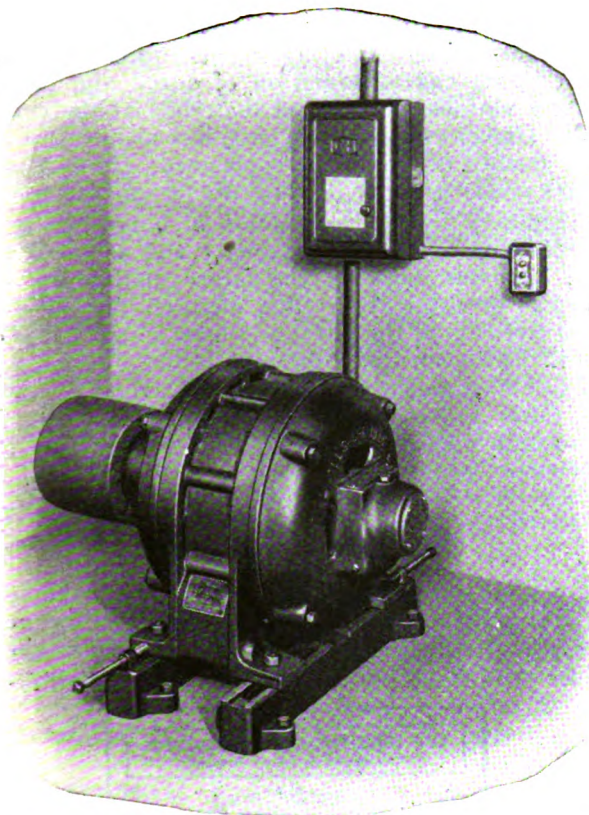
all Westinghouse single-operator welders. It insures a high-speed of welding, and a machine whose generator voltage responds to any changes in arc conditions this tending to maintain a constant rate of fusion of the electrode.

The unit is rated at 200 amperes, 1 hour, 50 deg. rise on a resistance load at 25 volts which conforms to the standard rating of the National Electrical Manu-

facturers Association. The motor is wound for 220 or 440 volts and is assembled with the necessary connections made for operation from a three-phase 60 cycle circuit. If it is desired to operate the unit from a 440 volt, three-phase, 60 cycle circuit, it is only necessary to replace the operating coil on the magnetic starter, and to reconnect the motor leads.

Line Start Induction Motors

A line of squirrel cage induction motors suitable for starting on full line voltage is being placed on the market by Allis-Chalmers Manufacturing Company. These motors are normal torque, high reactance machines and will not draw starting current in excess of the limits recommended by the Electrical Apparatus Committee of the National Electric Light Association. They are built in ratings $7\frac{1}{2}$ to 30 hp., 600



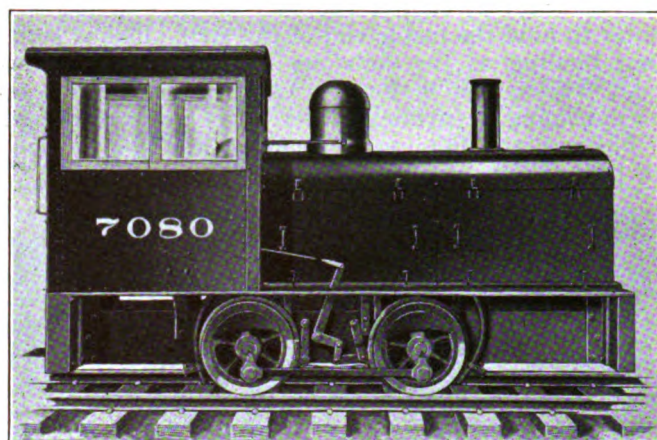
to 3,600 rpm., low voltage, and are available with either sleeve or roller bearings. All superior features of Allis-Chalmers construction as employed in squirrel cage motors are maintained in this new line. A magnetic switch with push button control is the only starting equipment required.

Gasoline Driven Locomotive

A gasoline locomotive entirely new in design and drive principle has just been brought out by H. K. Porter Company of Pittsburgh, Pa.

The power plant, clutch and transmission are mounted on steel sub-frame and form a straight line drive to the reverse unit. This sub-frame acts as a torque arm pivoted on the rear axle and spring suspended at the front to the main frame. By an ingenious arrangement the weight of the rear end of the sub-

frame is carried on the main frame by a coil spring. The result is that all the vital parts of the locomotive namely, the engine, radiator, clutch transmission and reverse unit are mounted on a sub-frame which is

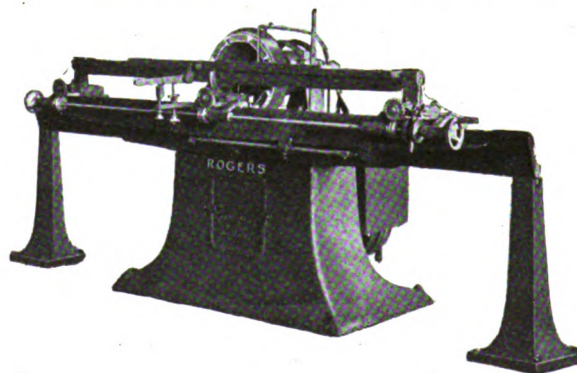


spring suspended to a spring suspended cross-equalized main frame.

The main frames and bumpers are made of rolled steel slabs and same as used on the famous Porter steel works locomotives. The massive frame and bumper construction is shown by the illustration. The running gear, including steel tired driving wheels, side rods, driving boxes, shoes, wedges, springs, etc., is the same as on the Porter steam dinkey.

Full Automatic Sectional Wheel Grinder

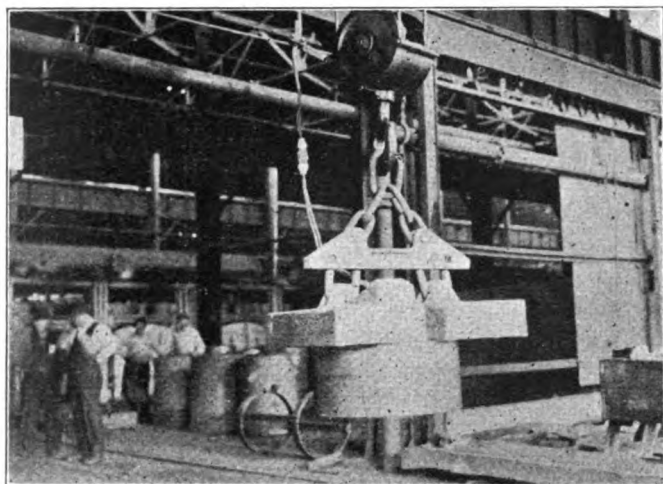
Samuel C. Rodgers & Company, of 191-205 Dutton Avenue, Buffalo, N. Y., is putting out a new heavy duty grinder adapted for grinding shear blades up to 146 in. long. The design includes the new 14 in. sectional grinding wheel, having eight segments, mounted in a strong steel chuck with simple adjustment for securely holding and replacing segment; effecting a great saving over the solid wheel type. The features of the grinder are: faster grinding without burning knives; improved water attachment; spring cross feed; heavy yoke bottom supports with adjusting nut to eliminate vibration; double ratchet feeding with automatic stop; increased speed; ball bearing if desired;



direct motor drive which includes built in standard 5-hp., 60 cycle motor with starter, extended shaft, brackets, etc.; belt drive with tight and loose pulleys, 8 in. in diameter with $3\frac{1}{2}$ in. face to run 1,150 rpm.; leather belts; emery wheel dresser, wrenches, etc.

Lifting Magnet Handles Strip Steel

Strip steel coils, before they leave the coiling machines at the Superior Steel Corporation's plant, Carnegie, Pa., are bound with a single band around the middle of the circumference and another across the center to hold the inside end of the strip. This is sufficient binding as the coils are immediately piled on small trucks, and in lots of 12, they are carried to the annealing department; there they are transferred to buggies, the binding is removed and the buggies are pushed into annealing furnaces.



All of the coils, regardless of their weight, the thickness or width of the metal, are 28 in. across the outer diameter. Because of this, the center hole will vary between 10 and 20 in. in diameter. The coils run from 1200 to 1800 lbs. in weight while the strip varies in width from 14 in. to 20 in. Every coil is bound in the same manner.

In the annealing department, two E.C. & M. No. 2-F lifting magnets on a special spreader beam handle these strip steel coils. Either one of these magnets will lift the heaviest coil if that coil is bound securely, but with the present simplified method of binding, the center turns of the coils will pull out under the pulling power of a single magnet. It was, therefore, a simple problem in economics, two magnets versus more elaborate binding of every coil, the solution of which dictated the purchase of the two magnets.

As stated before, the outer diameter of every coil is 28 in. The spreader beam designed for this job, holds the two lifting magnets so that their centers are exactly that distance apart, thus bringing the center of pull of each magnet above the outer edge of the coil to be lifted. The major part of the lifting of a coil is done at the outer edges so there is no tendency for the steel strip to come uncoiled. With two lifting magnets, the Superior Steel Corporation has done away with elaborate, expensive binding of coils on a job where, under any circumstances, the binding can only be temporary.

New Tube Reducing Mill

Manufacturers of seamless and lap weld tubing will be interested in a new reducing mill which has many unique features, which appeal to the producers of tubing. In the manufacture of tubing it has been rather difficult and expensive to make the smaller

sizes, i. e., sizes smaller than 2½ in. O. D. In the ordinary methods of manufacturing seamless tubes it is usual to pierce and roll the blanks at approximately 3 in. O.D. and then reduce the diameter in a continuous duo-roll mill. In this mill each successive roll stand has its axis at 90 deg. to the preceding stand, in order to eliminate the rib formed at the meeting of the rolls and also to reverse the pressure on the tube. This type of mill has served well, but has many disadvantages. The new design has incorporated the following features that are worthy of notice. It has three rolls in the same plane in each housing.

Each roll encloses 120 deg. of the circumference of the tube. The rolls are mounted on roller bearings, which, together with the gearing, are completely enclosed and run in oil.

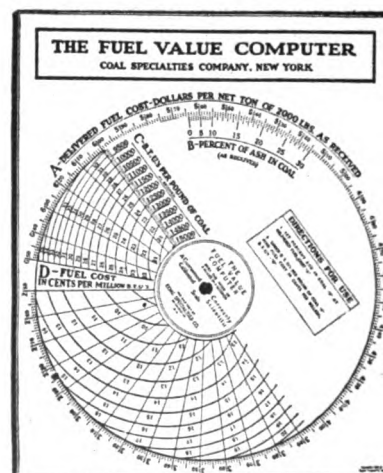
The roll stands are all practically alike except that the roll assembly is shifted 180 deg. in each succeeding stand. The drive shaft always comes out in a horizontal line on the same side of the mill, and these shafts are driven through speed reducers by variable speed motors, each stand having its individual motor. This permits exact regulation of speed and permits handling various gauges and materials at the correct speeds. Higher reduction per pass, less maintenance and higher quality of product are obtained. These unusual features are covered by pending patent applications.

Machinery for the production of hot rolled seamless tubes up to 16 in. in diameter and as small as 1 in. in diameter, both by the pilger method and the American or automatic rolling method, have been designed embodying the latest and most modern practice of both European and American mills.

The Wellman-Seaver-Morgan Company, Cleveland, Ohio, are now prepared to furnish a complete line of tube mill machinery including these new type reducing mills described above.

Fuel Value Computer

For a long time those having to do with the selection of coal have been seeking some satisfactory means by which the coals they were considering might be evaluated upon a basis of facts. Some attempts at



doing this had been made in the past, but very little real progress was apparent until the advent of an ingenious instrument known as The Fuel Value Computer, marketed by the Coal Specialties Company, 50 Church Street, New York, and which has just recently become available.

TRADE PUBLICATIONS

Allen Bradley Company, Milwaukee, Wis., has issued bulletins and price sheets, for insert into their catalogue, covering starting switches, starters and electric controlling apparatus.

Webers No. 48 insulating cement is featured in an 8-page pamphlet and a letter folder describing efficiency, ease of application, durability and the reclaiming feature, by Insulating Products Company, Chicago, Ill.

A folder from The Paul Maehler Company, 2210 W. Lake Street, Chicago, describes and illustrates the Maehler-universal heater for ovens.

The General Electric Company, of Schenectady, N. Y., describes in a folder G. E. A. 712A the type B. T. A. motors for a.c., adjustable speed with shunt characteristics.

Landis Tool Company, Waynesboro, Pa., circular H-27 describes and illustrates 30 in., 40 in. and 50 in. swing roll grinders with a full table of specifications.

A bulletin from Carl Still Corporation, 114 Liberty Street, New York City, describes the "Indugas" vertical chamber gas oven recuperative or regenerative and heated with its own or auxiliary gas supply.

The Railway Industrial Engineering Company of Greensburg, Pa., shows in a reprint of a Monel metal folder from an advertisement of the International Nickel Company, the R. & I. E. high pressure electric switches.

A letter folder from Laclede Christy Clay Products Company, St. Louis, Mo., describes the qualities of different varieties of fire brick—"Some Brick" say the various users quoted.

Thermostats for industrial applications is the subject of a folder from Robertshaw Thermostat Company, Youngwood, Pa., illustrating the No. 3 high pressure thermostat for 1550 deg. F. regulation within 5 deg. F. in the heat treating department of Stewart Warner Speedometer Corporation.

The annual report of the American Telephone & Telegraph Company for the year 1927, 30 pages, published 195 Broadway, New York City, is ready for distribution.

The Association News, the official organ of the Texas & Pacific Railway, January number, is devoted to the subject of Vanadium. Reprints may be had from the Vanadium Corporation of America, 120 Broadway, New York City.

"Designing Concrete for Workability" is the title of bulletin 336 by the Celite Products Company, 11 Broadway, New York City. Suggestions are given for various mixes and tests cited to indicate workability and strength.

A folder from the Erie City Iron Works, Erie, Pa., describes and illustrates the fourth steam unit at the River Rasin Paper Company, at Monroe, Mich. Each unit consists of one 1296 hp. Erie City three-drum boiler with an Erie City water-cooled ash screen and two unitive pulverizers.

Bulletins of the Clark Controller Company of Cleveland, Ohio are being distributed as follows: No. 104-B Edgewound resistors, No. 102-C "3C" brakes, No. 103-A "3C" flexible couplings, No. 105-B starting switches for a.c. motors and No. 110 "3C" push buttons. These bulletins are fully descriptive and contain many illustrations.

The Transatlantic Trade which is the trade magazine of the American Chamber of Commerce in Berlin, Germany, has come out with the twenty-fifth anniversary number January 1928. The number is devoted to the presentation of the work of the chamber in the furtherance of commercial relations and is illustrated to bring the reader in close personal acquaintance with its officials.

The International Nickel Company, 67 Wall Street, New York City, has issued the "Monel" Metal and Nickel Buyers' Guide," fall 1927, 20 pages. The buying companies are listed under products headings alphabetically arranged.

The Timken Roller Bearing Company of Canton, Ohio, shows on a letter folder graphs of the give and movement of pinion and gear as affected by Timken roller bearings in comparison with usual types.

The Rollway Bearing Company of Syracuse, N. Y., has issued recently a new catalogue 4-A on their Wide Series and Utility type of bearings and also a number of bulletins as follows:

Bulletin No. 53—Self-aligning pillow blocks equipped with Rollway adapter type bearings to fit standard commercial shafting.

Bulletin No. 54—Various precision types of Rollway radial bearings.

Bulletin No. 55—Self-aligning pillow blocks equipped with standard Rollway bearings.

Bulletin No. 56—Large Rollway bearings in the recently adopted international sizes.

The new water filtration plant of the City of Wenatchee, Wash., is described in a paper by Fred J. Sharkey, city engineer, and S. De Moss, structural engineer, which has been reprinted and is being distributed, by the De Laval Steam Turbine Company, of Trenton, N. J., builders of the pumping equipment. Water is taken from the Columbia River, which is subject to considerable fluctuations in level at this point, through an intake pier and is conducted to an electrically operated pumping plant and sedimentation basins and filters located on the river bank.

"Nickel Alloy Resistors that do not Break" is the title of a folder from The Electric Controller & Mfg. Company, Cleveland, Ohio.

A bulletin describing sugar dust collection is issued by Dust Recovery, Inc., manufacturers of dust recovery apparatus, 15 Park Row, New York City.

TRADE NOTES

H. H. Peck, long associated with the steel industry in sales work, has been appointed district sales manager New York for the Egan-Johnson Steel & Iron Company, of Crum-Lynne, manufacturers of small and medium sized carbon and alloy steel castings. His office is at 114 Liberty Street, room 902, New York City.

* * *

Mr. E. G. Jarvis has just been elected chairman of the Metal Division of The National Association of Waste Material Dealers, Inc. Mr. Jarvis is president of the Niagara Falls Smelting & Refining Corporation, president of the American Boron Products Company, and chairman of the board of directors of the Ladle Ring Corporation of American.

* * *

The Shaw Crane-Putnam Machine Company, Inc., owned by Manning, Maxwell & Moore, Inc., announces the purchase of the Lamb & Nash Line of sheet metal machines. Included in the Lamb & Nash line are the rotary gang slitting machines, which are giving a very good account of themselves in many plants throughout the country, shearing tin plate, hot mill sheets, blue annealed, brass, copper, aluminum and all classes of cold-rolled steels, which come hard, half hard and dead soft. Another item on the list deserving full attention is the Lamb & Nash squaring shear, a machine which promises unusual service to the sheet metal mills. The future manufacture of all machines of the Lamb & Nash line will be carried on at the Putnam Works of the Shaw Crane-Putnam Machine Company, Inc., Fitchburg, Mass.

* * *

The widely used Carbic acetylene floodlight which has aided thousands of contractors, road builders and others to operate night shifts economically, and the Carbic acetylene generator, as well as other Carbic equipment utilizing acetylene, formerly sold by the Carbic Manufacturing Company, Duluth, Minn., will in the future be distributed exclusively by the Oxweld Acetylene Company, 30 East 42nd Street, New York. The processed carbide in cake form, sold under the trade-mark Carbic, for Carbic lights and generators, will be distributed exclusively by the Union Carbide Sales Company, New York, through its nationwide chain of warehouses.

* * *

The Virginia Public Service Company of Newport News, has placed an order with the Semet-Solvay Engineering Corporation of New York, for nine stacks of Steere sheradized cooling coils. These coils, together with two pumps, complete a recent washer cooler installation furnished by the Semet-Solvay Engineering Corporation.

* * *

The School District of Altoona, Pa., has retained H. O. Swoboda, Inc., for increasing the capacity of their central light, heat and power plant. The additional demand will be caused by a large extension to their Senior High School which is under construction at the present time, and which will be completed the latter part of this year.

Allis-Chalmers Manufacturing Company, Milwaukee, announces the appointment of Mr. R. T. Stafford, formerly district manager of the Seattle office, as assistant manager of the electrical department in charge of sales and engineering at Pittsburgh Transformer Works.

Mr. John Alberts of Seattle office has been appointed district manager, succeeding Mr. Stafford. The Seattle district embraces the states of Washington and Oregon, having a branch office located at Portland.

* * *

Orders for Freyn-Design pressure burners for blast furnace stoves have just been received by Freyn Engineering Company from Sharon Steel Hoop Company, Sharon, Pa., and Republic Iron & Steel Company, Youngstown, Ohio. This increases the number of Freyn-Design pressure burner installations to include eight different plants.

These burners will be of the unit or integral type and will be motor driven. Both installations will have automatic control, governing the blower speed to supply the correct amount of air for the gas available. For the Republic Iron & Steel Company installation a large burner, capable of burning 14,000 cu. ft. of gas per min., will be supplied. This size of burner is required because of the large size (95,000 sq. ft. heating surface) stove on which the burner will be operated.

* * *

At a meeting, March 6, organization changes were made by The Roessler & Hasslacher Chemical Company, New York City. The following men now constitute the board of directors: Mr. W. A. Hamann, chairman of the board; Dr. H. R. Carveth, Mr. P. Schleussner, Mr. M. Kutz, Dr. M. J. Brown, Mr. C. Dill, Mr. A. Frankel, Mr. G. E. Warren, Mr. J. M. Gifford.

* * *

The Cleveland Electric Tramrail Division of the Cleveland Crane & Engineering Company, Wickliffe, Ohio, announces the appointment of Leeds, Tozzer & Company, Inc., 75 West Street, New York, N. Y., as representatives of their tramrail system in Manhattan, Bronx and Staten Island, New York.

* * *

The Sloss-Sheffield Steel & Iron Company has placed an order with the Semet-Solvay Engineering Corporation, of New York, for 26 stacks of Steere cooling coils. They will be used on the gas scrubbers to provide increased capacity. The stacks will be 40 tubes high and will be zinc coated by sherardizing to resist corrosion.

* * *

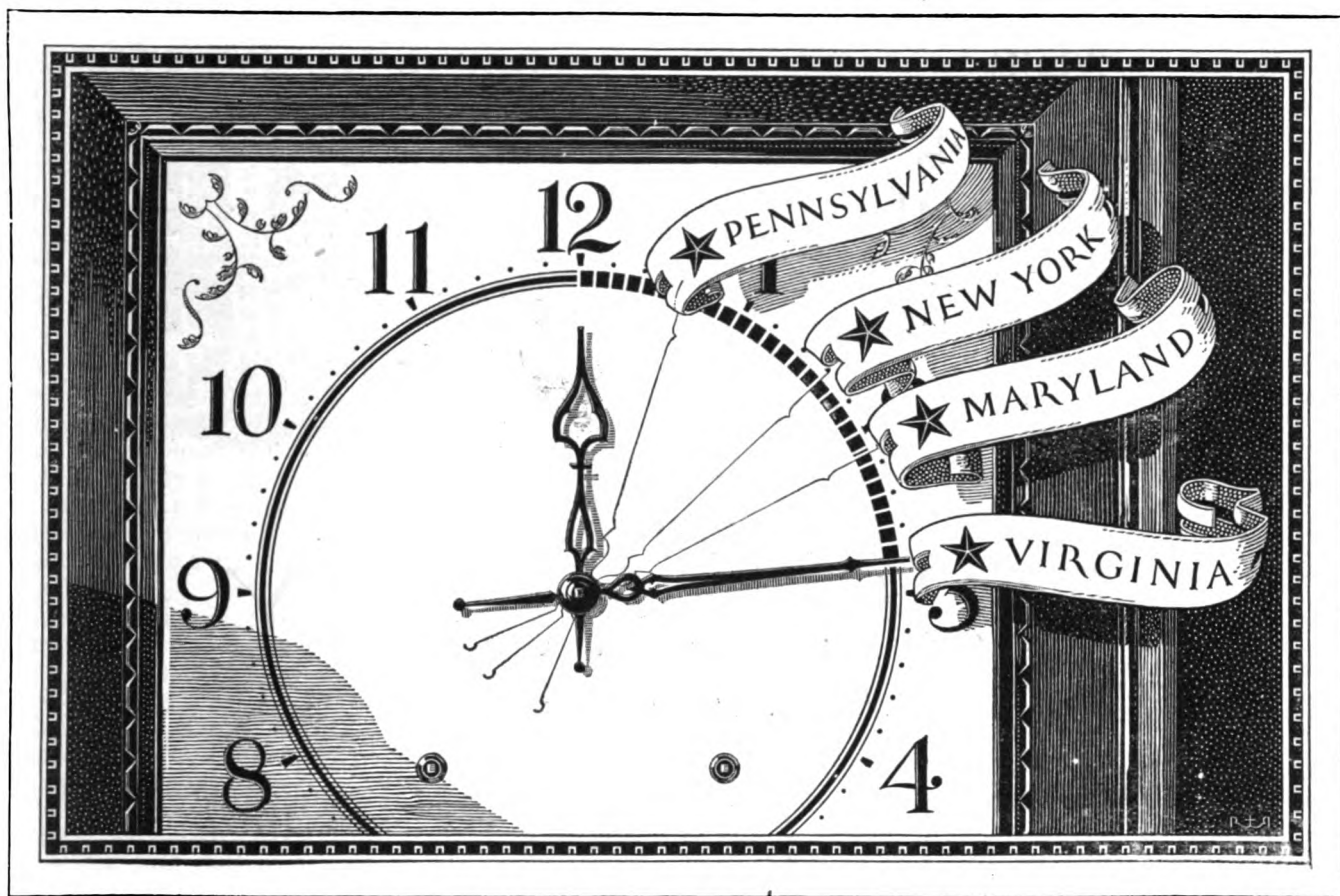
The Buckeye Steel Casting Company, Columbus, Ohio, has placed an order with Freyn Engineering Company for two additional Freyn-Design, fire tube type, waste heat boilers. They will be installed in connection with open-hearth furnaces. This order is a result of the satisfactory service received from the initial boiler of this type which was installed about a year ago.

* * *

The Societe Lorraine des Acieries de Rombas is proceeding with the construction of No. 3 blast furnace at Rombas, Moselle, France, under the direction of Mr. Emile Hemmer, director of Mines and Works. Freyn Engineering Company, of Chicago, has been retained in a consulting capacity for the work, particularly to determine the size and type of furnace best suited to the raw materials available.

2400 Miles

\$1700 worth of Business in 14 minutes



An Advertisement for Bell Long Distance Telephone Service

A PENNSYLVANIA cement company called by Long Distance and secured a 30-ton order from a town in New York. Telephone charges \$1.95. A 24-ton order from a Maryland town; charges \$2.50. A 20-ton order from a Pennsylvania town; charges 75 cents. And a 15-ton order from a town in Virginia; charges \$3.50. . . . Twenty-four hundred miles were "traveled"—there and back. Total orders secured, \$1700. Total charges, \$8.70. Talking time, 14 minutes.

So many businesses have found Long Distance indispensable in sales work that the "key town" plan has been developed as a further assistance and saving. By this plan key towns are selected. Each one of these is central

to all of the towns in its trade territory. From the key towns in the various territories, the representatives cover the other towns by telephone, in minimum time and at low cost.

To facilitate the use of the key town sales plan, interested firms may arrange for credit identification cards to be issued to their traveling representatives.

Long distance telephone service can be custom-made to fit your business. Surprising how much long distance calls will do and how little they will cost. Ask the nearest Bell business office about the key town plan. . . . Calling by number takes less time. Number, please?



NEWS OF THE PLANTS

The Columbia Steel Corporation has started operations on a new battery of 23 Koppers-Becker by-product coke ovens at Provo, Utah. The company now has a total of 56 ovens with a capacity of 400,000 tons coke per year.

* * *

The Alan Wood Iron & Steel Company has now completed its program of modernizing, having placed in operation its north mill at Conshohocken, Pa., after complete rebuilding.

* * *

Mid-States Steel Company will be incorporated in Indiana with plans to acquire the Crawfordsville Wire & Nail Company of Crawfordsville, Ind., the Adrian Wire Fence Company, Adrian, Mich., and the Dwiggins Wire Fence Company, Anderson, Ind.

* * *

The Tennessee Coal, Iron & Railroad Company has put in operation new battery of 77 16-ton ovens at the Fairfield by-product plant. Work has been under way on this development for more than a year. The company will shortly blow in the first of the two 600-ton blast furnaces at Fairfield. The feature of these furnaces is the fact that all raw material will be handled mechanically for the utmost reduction of costs.

* * *

The American Steel & Wire Company stack "A" of the central group Cleveland, Ohio, produced in 1927 the largest gross tonnage among those of the United States Steel Corporation, having made 283,899 tons. The best day was June 22, 1926 when 1,003 tons iron was cast, no scrap other than the cleanup and runner scrap was charged.

* * *

John A. Roebling's Sons Company are planning to build a new rod mill of the continuous type at the Roebling, N. J. plant.

* * *

Sweet's Steel Company, Williamsport, Pa., has elected Joseph Kaye as chairman of the board. Daniel F. Swartz, president, Wm. P. Beeber, vice president, Chas. C. Steel, vice president in charge of sales, John F. Spotts, treasurer and Clarence L. Peaslee, secretary and general counsel.

* * *

The Carnegie Steel Company has been dismantling No. 1 blast furnace of its group of four at New Castle, Pa., on account of its high cost of operation and also because of its isolated location. This followed the elimination of high cost equipment at Columbus, Zanesville, Sharon and elsewhere, leaving a total for the company of 50 blast furnaces. The No. 1 stack at New Castle was 91 ft. 8 in. with a 20 ft. hearth built in 1872 and rebuilt in 1897.

* * *

Plans are underway providing for additions to the wide strip mills, finishing equipment and warehouse at Butler, Pa., of the Columbia Steel Company, subsidiary of the American Rolling Mill Company.

* * *

The Sheffield Steel Corporation, Kansas City, Mo., plan the construction of a fourth open-hearth furnace,

a blooming mill, billet mill, rod and bar mill, wire drawing equipment and additions to the bolt and nut department. The combination rod and bar mill will be built by the Morgan Construction Company, Worcester, Mass.

* * *

The plans for the merger of the Youngstown Sheet & Tube Company and the Inland Steel Company, which had been all but completed have been dropped due to failure of the interests involved to reach an agreement.

* * *

The Colonial Steel Company, Pittsburgh, Pa., has acquired a site in St. Louis, Mo., and will erect a building 50 x 80 ft. to be used for office and warehouse purposes.

COMING MEETINGS

April 19-21—American Gear Manufacturers' Association. Twelfth annual meeting. Rochester, N. Y., at Hotel Seneca. T. W. Owen, 3609 Euclid Avenue, Cleveland, is secretary.

* * *

April 23—American Welding Society. Annual meeting at New York. M. M. Kelly, 33 West Thirty-ninth Street, secretary.

* * *

April 23-24—American Society of Mechanical Engineers. First national meeting of materials handling division at Hotel Benjamin Franklin, Philadelphia. Calvin W. Rice, 29 West Thirty-ninth Street, New York, is secretary.

* * *

April 25-26—National Metal Trades Association. Thirtieth annual meeting at Hotel Astor, New York. J. E. Nyham, secretary, People's Gas Building, Chicago.

* * *

April 25-27—National Foreign Trade Council. Fifteenth anniversary convention, Houston, Texas. O. K. Davis, secretary, 11 Park Place, New York.

* * *

April 26-28—American Electrochemical Society. Spring meeting at Hotel Stratfield, Bridgeport, Conn. Dr. Colin D. Fink, Columbia University, New York City, is secretary.

* * *

June 14-16—American Society of Mechanical Engineers. National Oil, Gas and Power Meeting, Pennsylvania State College, State College, Pa. Calvin C. Rice, secretary, 29 W. Thirty-ninth Street, New York City.

* * *

June 25-29—American Society for Testing Materials. Annual meeting at the Chalfonte-Hadden Hall, Atlantic City, N. J. C. L. Warwick, secretary, 1315 Spruce Street, Philadelphia, Pa.



E. A. C. McKay is the new superintendent of the converter at the Joliet plant of the Illinois Steel Company, succeeding the late J. W. Murray.

* * *

Arthur Weil was made superintendent of the factory and Wm. Dezee assistant superintendent and Joseph Nelson foreman of the bolt and nut department at the Joliet plant of the Illinois Steel Company.

* * *

A. T. Hunt, formerly sales manager of the Seneca Iron & Steel Company, Buffalo, has been appointed district sales manager for the Eastern Rolling Mill Company, Baltimore, with headquarters in Baltimore.

* * *

Boyd B. Jack, vice president and general manager of the Empire Steel Company, taken over by the new Empire Steel Corporation, Mansfield, Ohio, has resigned.

* * *

Myron F. Westover, secretary of the General Electric Company for the past 34 years, retired on March 1 and William W. Trench, assistant secretary, has been elected by the board of directors to succeed him.

Mr. Westover has been actively identified with the electrical industry for 40 years, his first position being secretary to the late Charles A. Coffin, then treasurer and manager of the Thomson-Houston Electric Company. He was associated with Mr. Coffin until Mr. Coffin's death in 1926.

Mr. Trench, the new secretary, is a native of Staten Island. He is 36 years of age, a graduate of St. Lawrence University, the Brooklyn Law School and was admitted to the bar in 1916.

* * *

T. E. McLaughlin has been made superintendent of the Youngstown, Ohio plant of the Truscon Steel Company, succeeding Albert Senf who becomes manager of the company's new properties at Los Angeles.

* * *

Morton Skillin has been put in charge of the Boston office of Cohoes Rolling Mill Company, Cohoes, N. Y., maker of wrought iron pipe succeeding P. L. Watkins, who was transferred to Chicago.

Geo. W. Page, director of purchases for the W. A. Jones Foundry & Machine Company, Chicago, Ill., succeeds the late Thomas A. Jones, as vice president of the company. Mr. Page has been with the company many years.

* * *

Geo. E. Thomas, formerly associated with the Columbia Steel Company, Butler, Pa., and the United Alloy Steel Corporation, Canton, Ohio, has been made New York sales representative of the Empire Steel Corporation, of Mansfield, Ohio.

* * *

M. A. Jones, secretary of the Waddell Steel Company, has been chosen as chief clerk of the Niles, Ohio, plants of the Empire Steel Corporation.

* * *

D. R. Fithian, who for four years has been superintendent of the Waddell Steel Company, Niles, Ohio, has been made superintendent of the Waddell Works and the Falcon Works of the Empire Steel Corporation. Mr. Fithian had previously been superintendent of the sheet mills of the Sharon Steel Hoop Company, at Youngstown, Ohio.

* * *

After an absence of 20 years, Mr. E. E. Arnold has again become associated with the Westinghouse Electric & Mfg. Company, in the capacity of mechanical engineer for special assignment. Mr. Arnold has a background of 30 years' experience in designing, testing, consulting and executive capacities pertaining to mechanical engineering.

* * *

Dr. Harvey Nathaniel Davis has been elected president of the Stevens Institute of Technology, Hoboken, N. J., succeeding the late Dr. Alexander C. Humphreys. Dr. Davis has been professor of mechanical engineering at Harvard University since 1919.

* * *

W. P. Bradley has been made assistant to the vice president, E. A. Balsey of the Wheeling Mold & Foundry Company, Wheeling, W. Va. Mr. Bradley had been foundry superintendent for the American Bridge Company, Ambridge, Pa.



G. C. Fogwell recently became connected with the sales department of the Alan Wood Iron & Steel Company, Widener Building, Philadelphia, Pa. Mr. Fogwell had been former district sales manager for Jones & Laughlin Steel Corporation at Philadelphia.

* * *

Jack T. Richards has been made superintendent of the hot mills of the Weirton Steel Company, Weirton, W. Va., succeeding Walter Kaiser. Mr. Richards has been with the Weirton Company for 16 years.

* * *

Joseph H. Dillon, chief engineer at Coatesville, Pa., for the Bethlehem Steel Company, has resigned to become connected with the International Harvester Company, Chicago.

* * *

Frank G. Lukey formerly Western manager for A. Milne & Company, New York, resigned to become associated with Ziv Steel & Wire Company, Chicago as district manager at San Francisco.

* * *

Bennet Chapple, director of publicity for the American Rolling Mill Company at Middletown, Ohio, has been elected a vice president in charge of advertising.

* * *

Charles M. Schwab, chairman of the Bethlehem Steel Corporation and president of the American Iron and Steel Institute will be awarded the Bessemer gold medal by the British Iron and Steel Institute in London, May 3. The medal awarded annually from funds left in trust by Sir Henry Bessemer is for distinguished merit in the promotion of the metallurgy of iron and steel. Mr. Schwab is an honorary vice president of the British Institute.

* * *

Bertram D. Quarrie of Cleveland, has been elected president of the Oliver Iron & Steel Corporation, Pittsburgh, to succeed Henry Oliver, who had resigned to become chairman of the board of directors.

The new president assumed his new office April 2. He was formerly connected with the American Steel & Wire Company and Otis Steel Company, both in Cleveland.

Henry F. Schmidt, consulting engineer of the Westinghouse Electric & Mfg. Company, South Philadelphia Works, was awarded the medal of the American Society of Naval Engineers for the best article submitted during the year 1927. Mr. Schmidt, besides being awarded a gold medal, was given an honorary life membership in the society and a cash prize for his excellent and well-illustrated paper, entitled "Some Screw Propeller Experiments with Particular Reference to Pumps and Blowers."

* * *

John E. Frederick, general manager of the Kokomo Steel & Wire Company has declared his candidacy for the democratic nomination for governor of Indiana.

* * *

Mr. Howard Bruce, resigned as president of the of the Bartlett Hayward Company, and was elected chairman of the board, at a meeting of the directors held on February 26. Mr. Howell Fisher, who has heretofore been first vice president and general manager, was elected president. Mr. Albert C. Bruce was elected a vice president. The other officers of the company were re-elected. Mr. Bruce has been president of The Bartlett Hayward Company for 18 years. Mr. Fisher has been vice president for 12 years.

William C. Sproul Dead

William C. Sproul, former governor of Pennsylvania died at his home, Lapidea Manor, near Chester, Pa., March 21. Mr. Sproul who has long been associated with the refractories industry became identified with steel industry through his position as chairman of the board of the General Refractories Company. He was a prominent financier and was actively interested in many lines of business, including publishing, banking, railway, and shipping operations and coal mining. Besides he occupied an important place in politics. His activities in behalf of improved highways earned for him the title of "Father of Good Roads" in Pennsylvania. He was interested in sports and in the advancement of science, building and endowing the Sproul astronomical observatory at Swarthmore College.



THE STEEL PLANT ROLL TURNER AND DESIGNER

Recent Changes in Roll Department

William C. Oberg has been chosen to fill the new post of superintendent of roll departments of the Carnegie Steel Company, with headquarters at the com-



W. C. Oberg

pany's general office in Pittsburgh. He had been for nine years superintendent of the roll department, Homestead Works.

* * *

Stanley A. Daniels has been made superintendent of the hot strip department of the Trumbull Steel Company, Warren, Ohio, succeeding A. J. Schink. Mr. Daniels formerly in charge of the roll department of the Trumbull Steel Company has previously been connected with the Republic Iron & Steel Company, Youngstown, Ohio.

Harold P. Ingram succeeds W. C. Oberg as superintendent of the roll department, Homestead Works, of the Carnegie Steel Company.

* * *

J. A. Lafferty, formerly with the Weirton Steel Company, Weirton, W. Va., has been placed in charge of the roll department of the Trumbull Steel Company, Warren, Ohio.

A Five High Mill*

The tendency of the automotive trade, as well as other industries which have drawing and pressing operations in their process, is to require a minimum of gauge variation from side to center of the individual plate. This will require changes in the design of the mills. Variation from side to center of the individual plate is caused by wearing of the rolls and bending of the rolls, the latter generally known as roll spring. Design cannot alter roll wear but it can stop roll spring. This can be done by using rolls of large diameter which is generally considered not desirable from a rolling standpoint, or by backing up the rolls which come in contact with the hot steel by rolls larger in diameter and usually made of steel. This prevents the chill rolls from bending, just as the main rolls of a three high mill prevent the middle roll from bending. This principle has already been used successfully and the tendency now is toward an increasing popularity. Although we have not as yet heard of a five high plate mill, it certainly is not beyond speculation. Present ideas along these lines appear in the way of a tandem layout with the four high finishing stands composed of chilled iron rolls backed up by steel. The process will be standard tandem practice of roughing the slab down to a thickness where three or more passes in the finishing stand will be sufficient to take the thicker center out of the plate and produce a perfect surface.

*Extract from paper on plate mills, "Recent Developments on Tendencies," by F. M. Gillies. Presented at October meeting of American Iron and Steel Institute.

A.S.T.M. Permissible Variations in the Sizes of Cold-Finished Bars.

Specified Dimensions	Variations in Diameter, Thickness or Width, Inches							
	Rounds and Hexagons		Squares		Flats up to 1½ in., incl., in width		Flats over 1½ in. in width	
	Under	Over	Under	Over	Under	Over	Under	Over
Up to 0.3 in., inclusive	0.002	0	0.003	0	0.003	0	0.005	0
Over 0.3 to 1 in., inclusive	0.003	0	0.004	0	0.004	0	0.005	0
Over 1 to 2½ in., inclusive	0.004	0	0.005	0	0.005	0	0.006	0
Over 2½ in.	0.005	0	0.006	0	.....	.....	.....	.....
Over 2½ to 4 in., inclusive	.....	.....	.....	.....	.....	.....	0.007	0
Over 4 to 6 in., inclusive	.....	.....	.....	.....	.....	.....	0.010	.....



THE STEEL PLANT BRICK MASON

New Refractory Ore Is Found in Mississippi

Only a short time ago a refractory mineral known as baukite was found in Mississippi along the Gulf, Mobile and Northern Railroad. This deposit, which is in Winston County, is said to be the largest of three deposits of this material known to exist in the world.

Baukite is understood to be a non-spalling silicate and to offer a refractory for furnace lining, glass pots and other uses wherever high heat resistance is desired.

High-Temperature Whitewash

Whitewash to be used in improving the appearance of brickwork in boiler settings and other places where it is subject to heat has been devised by Arthur, Mitchener and Withrow of the Ohio State University. They recommended the following procedure in describing their work:

"Prepare a thin slurry by stirring finely ground lime into five gallons of water. Slowly add, with stirring, 5 lbs. of salt, 5 lbs. of plaster of Paris and one-half pint silicate soda. Apply immediately with a paint brush to brickwork. Addition of the silicate too quickly or in excess will cause the slurry to become thick and useless as a paint."

—Ind. & Eng. Chem.

Refractory Problems of Electric Steel Foundries

The joint committee on foundry refractories has been active in several different ways recently. At present the subcommittee on survey for the electric steel castings industry is hard at work on the refractory problems of the electric castings foundries. This subcommittee is planning to circulate a questionnaire to all electric steel foundries to obtain additional information to aid them in their studies. They hope that the response to this will be generous. The committee is composed of the following members: Lee Everett, chairman, Illinois Clay Products Co.; J. M. Geopferd, Racine Steel Castings Co.; W. Harvey Payne, Pittsburgh Electric Furnace Co.; P. C. Leonard, General Refractories Co.; Samuel Arnold, Heroult Electric Furnace Co.; H. L. Smalley, Harbison-Walker Co.; A. C. Gierach, American Manganese Steel Co.; and F. W. Brooke, William Swindell Brothers.

Ashland Firebrick Company Appoints Ohio Representative

George G. McClure, formerly purchasing agent of the American Rolling Mill Company of Middletown, Ohio, and more recently Chattanooga representative of the Ashland Firebrick Company, has been transferred to the main office of that company at Ashland, Ky. Mr. McClure will look after the Ohio territory.

Burning Refractories with Stokers

Dense columns of smoke and flame from the stacks, have long evidenced the fact that fuel was being very poorly burned in fire brick plants. This practice, while generally recognized as being inefficient, has prevailed for years with no satisfactory remedy. Some plants have, to some extent, improved over the general practice by carefully regulating their firing cycles and burning conditions but the inefficiencies common to hand firing or intermittent charging still remained.

To prove the practicability of stoker firing, The Massillon Refractories installed a stoker manufactured by the Iron Fireman Manufacturing Company of Portland, Ore., on a small rectangular experimental kiln of about 4000—9-in. capacity.

Briefly this stoker consists of a hopper from which a screw feed conveys the slack

coal into the retort and a fan which furnishes the air for combustion, both driven by a constant speed motor. This motor rotates the fan at a constant speed, the air being varied by a damper. The air is carried into the pit (which is sealed air-tight) under the cast iron plates of the combustion chamber and allowed to enter the retort through perforated cast iron tuyere blocks, where it is utilized for combustion immediately. The rate of coal feed is varied by a pall and ratchet mechanism. The fuel bed is kept in practically constant agitation by the entry of the coal from the screw. By the time the fuel is completely burned, it has traveled to the side of the combustion chamber where it rests on the cast iron dead plates (kept cool by the air entering beneath) from which place it is periodically removed by cleaning.

In the initial burn, there was so much doubt as to the results that rather than risk a kiln of ware, the kiln was simply filled with clay desired calcined. The



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results of this initial burn, however, were very satisfactory and the kiln was immediately filled with 9-in. straight brick, again fearing to set special shapes in same. The results of the second burn in this kiln, however, were satisfactory again in every respect.

In the next 20 burns, ware of every description was fired with excellent results from cone 6 to 15. The coal consumed in these 20 burns was found to be 11.8 per cent less than corresponding burning with hand firing. The major saving, however, is the fact that a slack or cheap grade of coal was consumed in the stokers while a screened lump coal was used in hand firing. The delivered cost of this slack coal was 68 per cent of the cost of the lump coal formerly used, this giving a total saving in fuel of about 40 per cent per burn.

By this time, sufficient interest had been aroused to apply stoker firing to a 28-ft. inside diameter round kiln. The heat distribution was satisfactory in this installation and three or four burns were made without resetting the stoker. On these burns, the coal consumed was reduced 12.6 per cent which with the cost of the coal showed a saving of 40½ per cent as compared with hand firing. The power consumed will decrease the above figures, depending on power rates.

In addition to fuel saving, a considerable saving results in labor. Not only does stoker firing lighten the work of the fireman, thereby, enabling him to handle more kilns but in addition the plant is kept clean and no coal or ashes is spread around the whole kiln yard.

Another saving which has been especially noticeable with stoker firing is that the loss in burning is very small. In several burns the average of resets and broken ware was less than 1 per cent, which is a very marked improvement over hand methods.

When burning with stokers the entire kiln is under pressure. This accounts for the even distribution of heat and also permits the heat to be easily distributed by varying the size of the floor ports when found necessary.

It is impressive to observe a kiln being fired by stoker, at 2500 deg. F. of heat with absolutely no smoke issuing from the stack. This should prove of interest to plants located in cities where a strict smoke ordinance is enforced.

Segregation in Storage Bins*

By C. E. Balest

One of the problems confronting the fire brick manufacturer at the present time is the separation of the coarse particles of clay from the fines in storage bins. Nearly all fire brick plants now crush their clays and store them in bins for wet pan use. Bins are also used to store an adequate supply of clay for stiff mud and dry-press brick machines.

*Abstract of a paper read at the Open Forum Session of the American Refractories Institute meeting, December 8, 1927, St. Louis, Mo.

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Clay is conveyed to the bins from the screen outlet either by belts or adjustable chutes and as the clay drops into the bins the coarse particles roll out to the edge of the pile, while the fine material builds up in the shape of a cone in the center of the bin. In drawing clay from bins in which this condition exists, the charge sometimes contains a very high proportion of coarse particles, while at other times the entire charge resembles flour. It is practically impossible to make a uniform product when such a condition exists and since uniformity is of vital importance both as to quality, size and workmanship, it makes the problem of particle separation of considerable interest.

From practical experience and research data it is well known that the grain size of the fire brick batch exerts considerable influence on the properties of the finished brick. Brick made from fine clay have a much higher drying and burning shrinkage than brick made from coarse clay of the same type. Therefore particle separation brings about variation in size.

Coarsely ground clays are difficult to work in a stiff mud machine and the product has a very poor appearance and low mechanical strength. Fine clays make a good looking brick, but cracking and warping are very apt to occur in such a mix. Variations in the proportions of grain sizes also cause differences in spalling resistance, hot and cold load carrying ability, resistance to abrasion and slag action.

There are two types of storage bins in general use; the rectangular bin with sloping bottom, and the cylindrical bin with conical bottom. Where the clay is delivered to the bins on a belt, it is believed that a series of baffles on the sides of the bins to deflect the clay stream would be effective in overcoming particle separation. Where the clay is delivered by an adjustable chute it is possible to get a fairly uniform mix in the bins by maintaining the optimum position of the discharge end of the chute.

Some plants using cylindrical bins with conical bottom have tried the following scheme with very good results. The clay is fed from the chute into a large round vertical pipe located directly in the center of the bin. This pipe has openings in it at intervals from the bottom to the top. While filling, the clay falls to the bottom of the tube and enters the bin through the opening, tending to prevent the formation of a cone and the coincident segregation. When the clay is withdrawn from the central pipe, it turns over on itself, causing a mixing action to take place which corrects segregation.

To overcome the evils of segregation, one concern built a long, narrow bin about 18 ft. in depth, with a number of openings in the bottom. A scraper conveyor was placed lengthwise over the top of the bin to receive and distribute the screened clay. The bottom of the conveyor has adjustable cross sectional slots every 3 or 4 ft. and these slots are opened just enough to permit an equal amount of clay to drop through each and still carry a portion to the extreme end of the bin.

A retrieving belt conveyor is located under the bottom of the bin. When clay is being drawn from the bin, two or more of the openings in the bottom



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are used simultaneously, thus permitting clay to be obtained from different parts of the bin at the same time.

This has the effect of re-mixing any segregation that may have taken place, either in stocking or drawing off at places in the bin which are becoming empty. In this way the filling is done horizontally and the drawing-off is done sectionally.

Some plants are using large bins with a number of partitions in them. They are filled separately but emptied collectively.

A very simple, yet effective, method of helping this condition is to have a small steel cylinder to which angle irons have been bolted, arranged at the discharge end of the chute. As the clay pours from the chute, the angle irons act as paddles and the cylinder revolves, thereby distributing the clay more uniformly over the area of the bin.

Some Notes on the Fuel Ratios in the Firing of Refractories*

By G. A. Bole†

The whole problem of kiln efficiency is so intimately tied up with five or six major items that the naming of any figure as a kiln efficiency factor is a precarious proposition. The following items are of major importance in obtaining good or poor results in kiln firing:

- 1—Kiln design.
- 2—Kiln proportions.
- 3—Grade of fuel used.
- 4—Firing schedule.
- 5—Method of stoking fires.
- 6—Method of setting ware.

It is only as each of these items are properly taken care of that a good fuel ratio figure can be obtained. Variations in any one of the above mentioned factors may cause what would otherwise be good practice to develop into poor practice.

I would much prefer not to answer the question put to me directly at this time as we hope to have much additional data on kiln efficiencies in the course of a couple of years. By way of starting the discussion, however, and at the risk of being criticized for my temerity, I will offer some tentative figures. If I may refer to fuel ratios in terms of heat treatment instead of in terms of product, I will feel much more secure of the accuracy of my data.

My information falls into three classes, namely:

- 1—Accurately and carefully checked data.
- 2—Checked information.
- 3—Second hand information.

Certain data was obtained by the Bureau of Mines crew on five plants firing refractory ware. Some figures were supplied by the plant owners prior to the

*Abstract of a discussion read before the Open Forum Session of the American Refractories Institute, December 7, 1927.

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running of the tests. Other figures are results of the work of the Bureau crew.

Other selected data was obtained from a survey of plants in the Kentucky-Ohio district. The figures were supplied by the plant management in each case from reasonably accurately recorded plant data. Much of the data obtained during the survey is not given due to questionable accuracy.

From the above figures and in light of a great deal of information which might be classed as second hand information, I offer the following for your consideration. These figures are for a medium sized round down-draft kiln (30 to 32 ft.), fired with a good grade of coal:

Cone 12 to 14, 1600 to 1800 lbs. coal per 1000 9-in. equivalent.

Cone 8 to 10, 1300 to 1500 lbs. coal per 1000 9-in. equivalent.

Cone 4 to 6, 1000 to 1200 lbs. coal per 1000 9-in. equivalent.

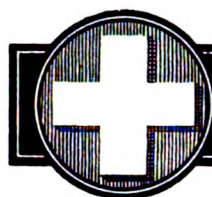
The figures are based on the assumption that it requires in the neighborhood of 8 days to properly mature a refractory at a temperature of cone 12 to 14 in periodic kiln practice; approximately 6 to 7 days for a cone 8-10 burn and 5 days for a cone 4-6 burn.

I have no checked information on the efficiency of tunnel kilns except on kilns firing high heat duty ware to cone 12-13. These figures vary from 900 to 1200 lbs., depending upon several factors, the most important of which is the grade of fuel used.

I have not sufficient information to compare with any degree of assurance the efficiency of rectangular and round down-draft kilns. The three or four kilns upon which accurate and comparable information is at hand, however, would seem to indicate that it is easier to get a uniformly well burned product from a well proportioned round down-draft kiln than from a rectangular kiln of equal capacity. The major difference seems to be in the greater ease of proper heat distribution in the round down-draft type of kiln.

It is claimed by tunnel kiln builders that Btu. can be traded between coal, oil, producer gas and natural gas when figuring fuel ratios in tunnel kiln practice. Assuming a figure of 1100 lbs. of coal per 1000 brick, the ratio for natural gas would be 13,200 cu. ft. per 1000. (Coal at 12,000 Btu. per pound and the gas at 1000 Btu. per cubic foot.) Oil of 19,000 Btu. per pound and a gravity of .90 (25 deg. Be.) will give a fuel ratio of approximately 1000 gallon per 1000.

Figures obtained from practice indicate that in periodic kiln operation, the fuel ratio for a cone 6 to 8 burn from natural gas is between 17,000 to 20,000 cu. ft. per 1000. A tunnel kiln operation firing ladle brick to a very low temperature (1900 deg. F.) claims a fuel ratio of 6000 cu. ft. per 1000. This is about the same figure as several ratios checked by the writer on plants firing face brick in tunnel kilns to about the same temperature. Several tunnel kiln practices are reported to be considerably better than the 100 gallons of oil above mentioned. One figure of 80 gallons of an 18 deg. Be. oil is reported but has not been checked. (Cone 12 burn.)



SAFETY FIRST IN THE STEEL PLANT

Jones & Laughlin Plant Goes 60 Days Without an Accident

The works of the Jones & Laughlin Steel Corporation on the Northside of the Monongahela River have completed 60 days' operation without a single disabling accident to any of its employees. Approximately 1,000,000 man-hours have been worked since the last lost-time accident. These works are located on Second Avenue and include the Pittsburgh by-product coke plant, Eliza blast furnace department, Keystone structural fabricating department and the Soho department, which is made up of an open-hearth department, spike factory, chain works and three plate mills.

Safety Talk

The Youngstown Sheet & Tube makes every effort to educate employees to prevent accidents and to teach them to cope with accidents when they do occur. The severe toll in injuries and deaths which the wheels of the world's industries exact, had convinced great companies of the need for accident prevention.

Now comes recognition of the need for that same sort of thought on the part of every individual. There are many more accidents to be classed as preventable than there are to be classed as unavoidable. Back of them all was the factor which looms as large as a balloon, in every human equation: the one word *carelessness*.

Pennsylvania Safety Congress

At the sessions held March 21-23, a number of subjects pertinent to the problems of the steel plant were discussed including the following: "Safety in the Machine Shop," by William J. Fisher, general superintendent, of A. B. Farquhar Company, Ltd., York, Pa.; "Cranes and Hoists," by J. A. Northwood, chairman Metals Section, National Safety Council, Bethlehem Steel Company, Bethlehem, Pa.; "Cars and Engines," by G. H. McClain, safety engineer, Jones & Laughlin Steel Corporation, Pittsburgh, Pa.; "Eye Protection in the Foundry," by K. V. Wheeler, Lebanon Steel Foundry, Lebanon, Pa., and "Goggles," by R. H. Lukenbach, safety engineer, Budd Manufacturing Company, Philadelphia, Pa.

Carnegie Steel Company Transportation Department Makes a Record

Mr. John Oartel of the Carnegie Steel Company, reports to the National Safety Council that from May 11 to October 5 inclusive, a total of 147 days in which they handled 233,938 cars, the transportation department of the Homestead Steel Works including the West Homestead Yard, the Howard Axle Works and the Carrie Furnaces did not have a lost time case. "These men have made railroading safe." It would require 3,875 locomotives to haul the trains and 19,375 men to make up the crews for the trains based on five men per crew.

Goggles

Eye accidents at the Mactezuma Copper Company, have been largely eliminated by the compulsory use of goggles. Every man whose duties are such that he might receive an eye injury must have a pair of goggles either around his neck or on his hat before he is lowered into the mine. Three pairs of goggles, which undoubtedly saved three men an eye each, are exhibited in a case near the shaft. In 1924, before the use of goggles was made compulsory, 102 eye accidents occurred; in 1926 there were only two such accidents, and undoubtedly the compulsory widespread use of goggles in the mine is responsible for practically all of the 1926 decrease in eye accidents.



Mr. H. E. Hensel is safety director for the Youngstown Sheet & Tube Company, Youngstown, Ohio. Records made by this company show that "safety first" is well taken care of by Mr. Hensel. He also takes care of statistics for the metals section of the National Safety Council.

National Electrical Safety Code

National Electrical Safety Code, fourth edition is now available at the Government Printing office, Washington, D. C. The procedure followed in the preparation of the present revision of the code differs from the former practice in that final decisions have been made by committees approved by the American Engineering Standards Committee. The book contains 484 pages of rules governing the erection, installation and use of electrical equipment of all types and for all purposes. In this edition a new section appears containing Safety Rules for Radio Installation. Many tables showing the permissible sag in wires of various compositions and the tensions of cables have been included. The price of the book is \$1.00.